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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See half-page Advertisement page 105, June 11.

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NOTE.—For detailed list of all surplus Government Property for sale, apply at the nearest Bookstall or to the Director of Publicity, Ministry of Munitions, Whitehall Place, S.W. 1, for *Surplus*, price 3d.

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BRICK and PIPE-MAKING MACHINERY, as follows:—

One Plaster Brick-making Machine, 23 in. diam., in pug barrel, capable of producing 12,000 bricks per day of 10 hours, fitted with pair of Horizontal Crushing Rollers, 20 in. diam. by 24 in. wide on face. Driven by strong Spur Gearing, with F. & L. Pulleys and Friction Clutch as a preventative against damage should machines become clogged. Complete One Plain Brick Die for ordinary bricks, and Improved Cutting Table.

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Tenders must be submitted not later than 10 a.m., July 31st. Further particulars, Tender Forms and permits to view can be obtained on application to the CONTROLLER, Plant and Machinery Section, Charing Cross Embankment Buildings, London, W.C. X 251

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GENERATING PLANT of Sub-Station, consisting:—

Three Hornsby water-tube Boilers, rated 10,000 lb. steam per hour; insured for 160 lb. pressure, only worked four years.
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The whole of steam, exhaust, and drain pipes, and valves.
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The above plant is ready for immediate shipment, and can be seen fixed as left off work, and will be sold in one or more lots.
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MISCELLANEOUS PLANT,
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Specifications and drawings may be obtained from the undersigned on payment of a deposit of one guinea, which will be returned on receipt of a *bona fide* Tender.
Tenders are to be received by first post, Monday, August 11th
W. A. VIGNOLES, Lt.-Col.,
Borough Electrical Engineer.
Corporation Electricity Works,
July, 1919. Grimsby. X 287

LONDON COUNTY COUNCIL.
The Council invites

Tenders for Repairs to Pave-

MENTS, Blackwall and Rotherhithe Tunnels.
Persons desiring to submit tenders may obtain the Specifications, Bills of Quantities, Form of Tender, &c., on application to the Chief Engineer, at the County Hall, Spring Gardens, S.W., upon payment to the Cashier of the Council of the sum of £3. This amount will be returnable only if the tenderer shall have sent in a *bona fide* tender, and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the drawings, specification and other contract documents may be inspected at the County Hall before the payment of the fee.
No tender received at the County Hall after 4 p.m., Friday, 1st August, 1919, will be considered.
JAMES BIRD,
Clerk of the London County Council. X 262

Re THE RUBEL BRONZE METAL CO., LTD., Small Heath Metal Works, Allon Rd., Birmingham.

To be Sold by Tender,

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(*b*) Plant and Machinery, Fixtures and Fittings, Foundry and Loose Tools, Foundry Moulds, Spare Parts, Electric and other Equipment, Motor Lorry and Car, and Office and Mess Rooms Furniture and Accessories.
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Mr. DAVID DAVIS,
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Orders to View, may be obtained from Mr. A. C. ALLDAY, General Manager at the Works. X 268

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Lecturer in Electrical Engi-

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Applications, stating particulars of training, works and teaching experience, accompanied by three testimonials, and giving the names of three Referees, should be received not later than August 2nd, addressed to the DEAN of the Faculty of Engineering, The University, Sheffield. X 190
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Forms of application may be obtained from Mr. A. H. BELL, Technical Institute, Sheerness, to whom they should be returned before 22nd July, 1919.
R. SALTER DAVIES, X 266
11th July, 1919. Director of Education.

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UNIVERSITY COLLEGE, NOTTINGHAM.
DEPARTMENT OF ENGINEERING.

LECTURER IN MECHANICAL ENGINEERING.

Applications are Invited for

the POST of LECTURER in MECHANICAL ENGINEERING, at a commencing salary of £300 per annum.
Particulars and forms of application, which should be returned not later than July 22nd, may be obtained from
J. H. SHIMELD,
Acting Registrar. W 269

UNIVERSITY OF BIRMINGHAM.

APPOINTMENT OF ASSISTANT LECTURER IN MACHINE DESIGN.

Applications are Invited for

this APPOINTMENT. Stipend £250 per annum.
The Candidate selected will be required to enter on his duties on the 1st of October next.
Further particulars may be obtained from the undersigned, to whom applications, accompanied by testimonials, should be sent not later than the 16th of August. X 280
GEO. H. MORLEY,
Secretary.

ABERDEEN.

ROBERT GORDON'S TECHNICAL COLLEGE.

ENGINEERING DEPARTMENT.

The Governors invite

Applications for the Post of

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JAMES McKENZIE,
Secretary and Registrar.
X 272

WOLVERHAMPTON
EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL SCHOOL.

Wanted, in September next,

a full-time LECTURER in Electrical and Mechanical Engineering. Degree and teaching experience essential. Salary £375, rising by annual increments of £15 to a maximum of £450. Official application form and further particulars can be obtained on sending a stamped and addressed envelope to the undersigned. Applications must be received not later than first post on Friday, the 25th instant.
A. S. ELFORD, M.A.,
Director of Education.
Education Offices, Wolverhampton.
July, 1919. X 226

SUNDERLAND EDUCATION COMMITTEE.

JUNIOR TECHNICAL SCHOOL.

Applications are Invited from

persons with scientific or technical qualifications for the POSITION of HEADMASTER of a Junior Technical School to be opened in October next.
The aim of the School is to give a three years' course of pre-apprenticeship training to boys from 13 to 16 years of age. Applicants should possess a University Degree, or its equivalents, and have had teaching and some administrative experience. The nature of any experience in engineering workshops or drawing offices should also be stated.
Applications, accompanied by three recent testimonials and three references, must reach the undersigned (from whom further particulars and forms of application can be obtained) by Monday, August 11th.
Salary:—£400 to £450 by annual increments of £10.
HERBERT RHEAD,
Chief Education Officer.
Education Offices,
15, John Street,
Sunderland.
July 10th, 1919. X 228

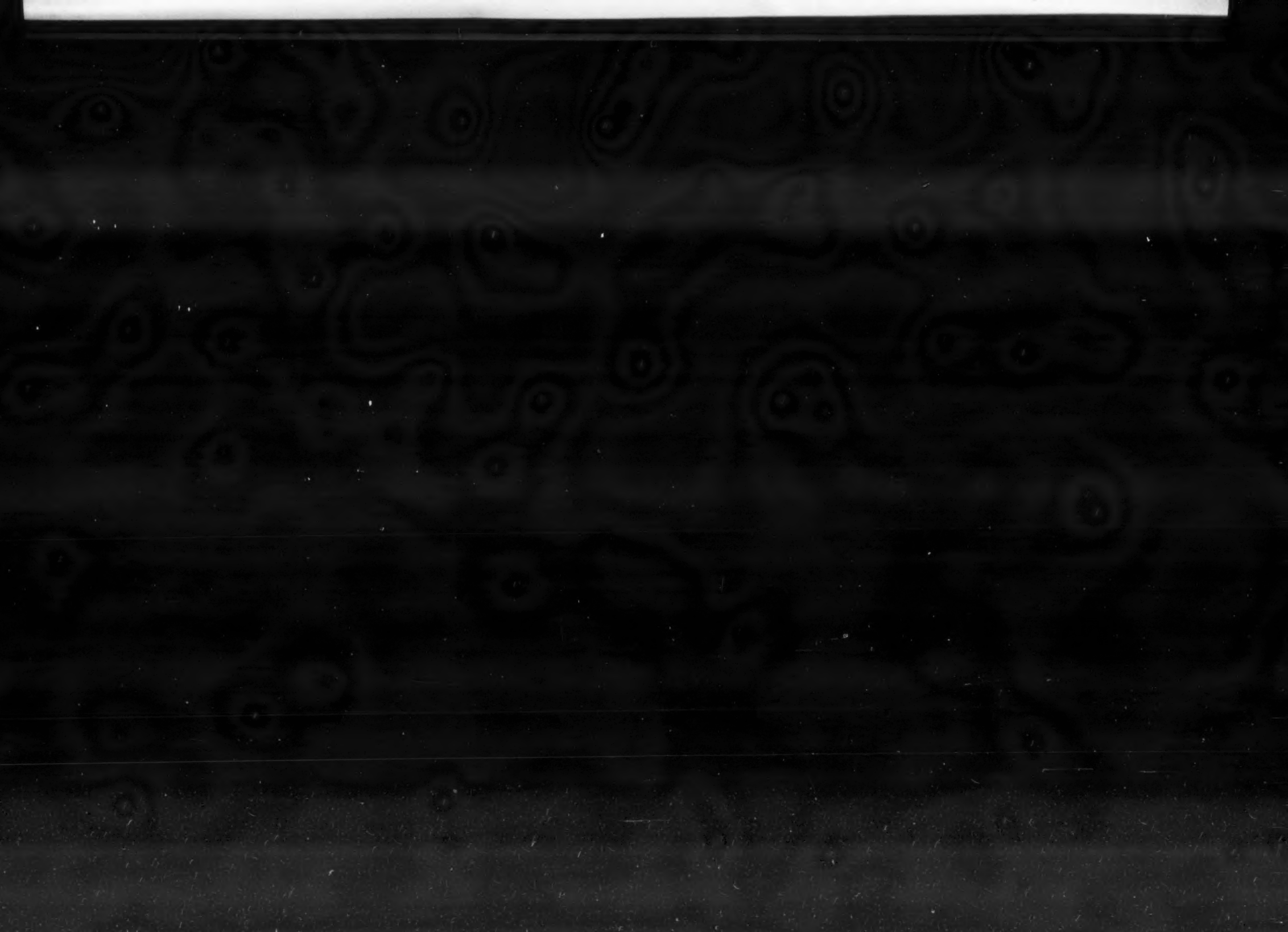
COUNTY BOROUGH OF BOLTON.

WATERWORKS ENGINEER.

The Waterworks Committee of the Corporation of Bolton are prepared to receive

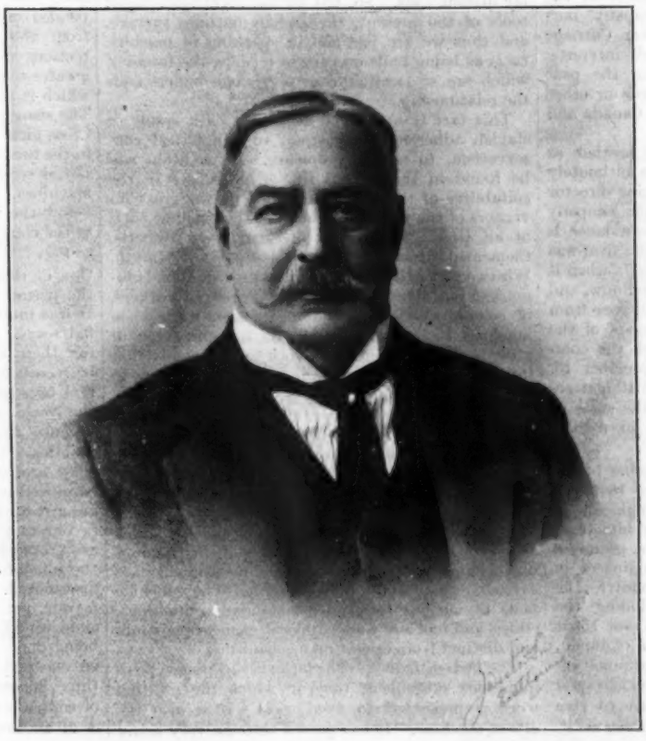
Applications for the Appoint-

MENT of Borough WATERWORKS ENGINEER. Commencing salary £750 per annum. Applicants are requested to state their age and experience in Designing, Constructing, Carrying Out and Management of Waterworks.
The person appointed will be required to devote the whole of his time to the duties of the office.
Applications accompanied by copies of three recent testimonials, which will not be returned, and endorsed "Waterworks Engineer," to be delivered to the undersigned not later than the 2nd August next.
Canvassing either directly or indirectly will be deemed a disqualification.
SAMUEL PARKER,
Town Clerk.
Town Hall,
Bolton.
14th July, 1919. X 242



THE LATE MR. ALBERT VICKERS.

By the widely regretted death of Mr. Albert Vickers, on Saturday forenoon, the 12th inst, at Compton Place, Eastbourne, where he has been residing for some time, there has passed away one who with rare personal gifts devoted a long and full life to the building up of a great business which was a valuable asset to the Empire, not only from the industrial point of view, but still more in the great task set during the strenuous years of the world war. He was largely responsible for the cumulative success of the Vickers Company, absorbing into it concerns contributing to the manufacture from the raw material of all munitions of war; he worked with unerring judgment in collecting a staff of experts, in encouraging invention and experiment, in improving producing appliances, and in co-ordinating management. Thus, when the war came the Government found a ready and willing means of quickly adding to the output of war materials and of educating other firms with no experience in this department of engineering. Indeed, few realise how much the nation owes to such firms for the part they played in helping to win the war.



Mr. Vickers was born at West Lodge, Sheffield, on September 16, 1838, son of Edward Vickers, a partner in a comparatively small steel-making business established in the later years of the eighteenth century, with works then at Millsand and at Wadsley, near Sheffield. After a "liberal" education, completed at Hameln-on-the-Weser, he entered the firm in September, 1854. He proceeded shortly afterwards to the firm's offices at Boston, U.S.A., in order to gain experience of their American trade, which was then very extensive, one of the manufactures being the drawing down of ¼-in. rods and the flattening of them for use in crinolines. The exports to the United States alone of this wire averaged 1,500 tons per annum. But with the financial crisis in the States the business came to an end in 1857, and Mr. Vickers returned to the Sheffield works. An effort had to be made to capture a greater part of the home trade, and the firm introduced into this country a process for making steel castings which had great influence in reviving their fortunes. The proof of success is found in the construction in 1863–4 of the River Don Works at Sheffield, the old works being too small. A few years prior to this—in 1856—the control of the business had been passed on from the father to the late Colonel Thomas E. Vickers, and upon Mr. Albert Vickers' return from the States there began that close association between the two brothers—the one a great metallurgist and the other a great commercial force—which has for so long and so pronouncedly influenced the destinies of the company. It is true that the survivors of the original firm and the early colleagues of the Vickers assisted in the laying of the foundation of the business of to-day, but for the great structure since erected the two brothers are entitled to the credit.

Courage in all commercial ventures and shrewd judgment of men and of the potentialities of business propositions were natural characteristics of Mr. Albert Vickers, and these were developed by travel and by greater knowledge of men and affairs. He was at home in the capitals of Europe, and crossed the Atlantic 34 times, beginning with the days of the old paddle steamers, whose discomforts were so vividly pictured by Dickens, and ending with the modern palatial leviathans, his last passage being on his return from Japan in 1902. Acquaintance with men of all nations had the effect of initiating important developments in the affairs of the company, a most influential one being that of gun construction. The late Mr. Robert Rintoul Symon, the vice-president of the Mexican Central Railway, introduced to Mr. Vickers in 1883 the late Sir (then Mr.) Hiram Maxim, who had a proposal for making a gun to load and fire itself. Symon and Vickers found the money, and all three were to share equally in the gain. Maxim had not then made complete drawings, so that here is one more proof of Mr. Vickers' courage. Nor had even a provisional patent been taken out; but, with financial assistance assured, experiments were proceeded with and success achieved. The Maxim Gun Company, with Mr. Vickers as chairman, was formed in 1884 and amalgamated with the Nordenfelt Company in 1888, becoming the Maxim-Nordenfelt Guns and Ammunition Company, the principal works, erected in 1888, being at Erith. There is no need to-day to write on the universal success of the Maxim gun.

Meanwhile metallurgical developments were being made at the River Don Works, due to the skill of the late Colonel Vickers, but these were influenced undoubtedly by the far-sighted administrative and financial policy of Mr. Albert Vickers. Instead of supplying others with steel to make guns, armour and the like, he urged successfully on his colleagues the policy of completing the guns and other products. Success having been achieved, he entered methodically upon the completion of a scheme of far-reaching consequence—the amalgamation under one control of works essential to the completion for service of a warship or merchantman. In this concept Mr. Vickers was a pioneer, and the great advantages following from its adoption have been widely recognised, and other concerns similarly situated in this and other countries have followed. The procedure has been criticised; but on wrong premises. The Vickers' scheme differs from the great trusts created in the United States, which are, as a rule, combinations of many concerns all of the same character, manufacturing similar products. The purport in this case is to cheapen production by a centralisation of control; perhaps, also, by confining each establishment to particular manufactures for which it is more or less specially suited. There is a strong suspicion, however, that in practice the greatest gain is attained by some artificial "balancing" of supply and demand whereby the selling price is controlled apart from the sounder method of fixing rates on the basis of the cost of production. The influence of competition towards effecting improvement may thus be forfeited. Mr. Vickers' aim, on the other hand, was the associating of many units, each separate, but forming an integral part of an industrial whole. The evolution followed on the recognition of the interdependence of these units. The builder of a warship, for instance, is dependent upon the steel maker, upon the constructor of propelling machinery, upon the manufacturer of armour, and upon the maker of guns and shot and shell. By uniting all these separate operators into an industrial communion there are eliminated divided interests, divided control, divided profits; there is no overlapping of energy, no conflict of self-interests; there is the equivalent of patriotic devotion to a common ideal. The result must be economy in the time and cost of production of the completed article and co-operation in devising improvements in all the constituents and in the whole.

To this end principally, almost entirely, by his own negotiation, Mr. Vickers arranged for the absorption into the Vickers Company in 1896 of the Naval Construction Works at Barrow-in-Furness; in 1897 of the Maxim-Nordenfelt Works; and in 1901 of the Electric and Ordnance Accessories Company and of the Wolseley Motor Works. In 1903 there was acquired a part share of the Chilworth Powder Works, and in 1906 of the Whitehead Torpedo Works. All of these establishments contribute towards the completion of a battleship, and by additions to the River Don

Works and to these various works it became possible for a battleship to be completed without outside help, except for the purchase of "proprietary articles." The result has been most beneficial from the national standpoint. In organising the staffs Mr. Vickers' judgment of character proved of great advantage to the company, while his continuous support and encouragement of research and experiment assisted towards perfection of design and of manufacturing processes. The co-ordination of all contributants to the planning and construction of a battleship led to great advances in design, so that the dominant work of Mr. Albert Vickers to this end has greatly assisted towards our naval and military successes, especially during the great world war. Moreover, by readily supplying to other firms without experience, plans and experience gained in manufactures, and by supplying from the works' staffs men to guide other establishments, the firm greatly influenced that rapid acceleration in the production of war material which was vital to the success of the allied cause. Quite recently the company purchased the business of the Metropolitan Carriage and Wagon Company and its allied interests. Associations were also effected during the past ten or fifteen years with naval concerns in other countries, notably Japan, Italy, Spain, Canada and the Argentines.

Mr. Albert Vickers succeeded his brother as chairman of Vickers, Limited (the name ultimately adopted), in 1909, having been a managing director for many years. The advance made by the company under his commercial and financial guidance is shown by the increase in capital since the firm was made a limited liability company in 1867, when it was 155,000*l.*, to over 21,000,000*l.* issued now, and by an increase in the number of employees from about 1,000 to 90,000 during some periods of the war. He resigned the chairmanship of the company on his eightieth birthday, on September 16, 1918, but continued to take an interest in all matters connected with the concern, although the state of his health prevented him from being in regular attendance at business for some time.

Mr. Albert Vickers was elected a member of the Institution of Mechanical Engineers in 1865, an associate of the Institution of Civil Engineers in 1868, and of the Institute of Naval Architects in 1897. He endowed a gold medal and a premium prize for the Junior Institution of Engineers in 1913. For his services to foreign countries he was awarded several decorations, including the Knight Grand Cross of the Order of Naval Merit of Spain, and the Order of the Rising Sun of Japan.

A man of few words, of clear and discriminating judgment, of quick and decided action, he accepted great responsibilities, and was ever ready to give credit to his colleagues of the staff for honest work. Indeed, he never lost an opportunity of expressing his appreciation of the cohesion, enthusiasm and singleness of purpose of the great army of workers who with him contribute towards a common end—the advancement of the concern. He took every opportunity of showing interest in the social affairs of the districts in which the works are situated.

In spite of his great successes and of his position as one of our great masters of industry, he was a very unassuming man, and took no part in public life beyond the duties incumbent upon him in connection with the firm and their works. Even then his speeches were brief yet forceful. Apart from his business he found most pleasure on the moors, and it is characteristic of him that he was the first to use smokeless powder in a sporting gun and one of the first to adopt the breech-loading sporting gun. He was a patron of Art, and his collection in his London residence at Cadogan-square is at least suggestive, particularly his Sargent's pictures, which are notable.

He was twice married—in 1861 to Helen Horton Gage, of Boston, U.S.A., by whom he had three children; she died in 1873. He married in 1875 Edith, daughter of John Foster, of Newhall Grange, Maltby, County York, who died in 1909. The only son of the second marriage, Mr. Vincent Cartwright Vickers, is a director of the Bank of England, the London Assurance Corporation and of Vickers, Limited; the elder daughter is married to Lieut.-Colonel the Hon. Stuart P. Bouverie, who earned the D.S.O. for his services in the war, and the other daughter, Miss Izme Vickers, has been her father's companion.

RECENT MACHINE TOOL DEVELOPMENTS.—No. II.

By JOSEPH HORNER.

IT is not a little remarkable that certain archetypal outlines in machine tools have become stereotyped in an almost endless procession of later tools, which often fulfil functions that differ widely from, and may be only remotely related to, those performed by their archetypes. It reminds one much of the persistence of primitive organic types, which survive in the higher forms in their evolution. There is no new creation involved, but every living organism, however highly elaborated, is obviously descended from homely and humble relatives in the far distant ages. So, too, in the highly developed tools of the present, the archaic outlines survive, and thus we are justified in speaking of machine tools as being built on certain models, the forms of which are so familiar that every one understands the relationship.

This fact is not to be explained as a result of slavish adherence to custom, to a practical conservatism, to mental indolence. Its solution will be found in the eternal fitness of things—in the suitability of the models designed by the great inventors of the past to the work of the machine tools of all time. The names of Maudslay, Roberts, Clements, Murray, Bodmer, Holtzapffel, Nasmyth, Whitworth, Sellers, Richards are familiar landmarks. But many others long forgotten, co-workers, or contemporaries, were doing pioneer work when machine tool design was in its nascent stage of growth, and they did their work so thoroughly that its broad foundations remain for their successors to build new machine tools upon. Perpetually one meets with designs which students and old men recognise at a glance as having been in existence two or three generations since, invented, forgotten or shelved, and re-invented, until one feels the force of the proverb that "there is nothing new under the sun."

It is intended to devote the earlier articles of this series to the very important subject of the framings of machine tools on which the mechanisms are carried, or into which they are built. These include beds of various forms, legs, standards, framings, slides, and tool and work supports, elements separate and distinct from operating mechanisms.

The Beds of Lathes.—The lathe is the archetype of numerous subsequent tools in which the rotating work is presented to fixed tools. It is also the oldest machine. It has passed through very many stages of development. It has to fulfil several functions. One of the most important is resistance to the stresses of cutting, another of equal necessity is that of guidance to the work-carrying heads and to the tool slides. Subsidiary matters concern details for special duties.

Lathe Bed Sections.—The bed is subjected to both torsional and bending stresses. The former increase with the radius at which the tool is operating. Using the present heavy cuts, this stress is very severe, and has been the reason for the adoption of several devices for its resistance, in the supporting elements of slide rest carriages. Bending stresses are resisted partly by the sections imparted to beds, partly by the number and dispositions of legs. Associated with these, though a subject apart, is that of the stiffness necessary to withstand vibratory stresses that are set up by heavy cutting, or are due to sudden hitchings of the tools, and jumps and jerks which arise from various causes. In lathes also with exceptions which occur chiefly in the heavier designs the cutting stresses are unbalanced, occurring on one side of the centre, which intensifies the causes that produce vibrations.

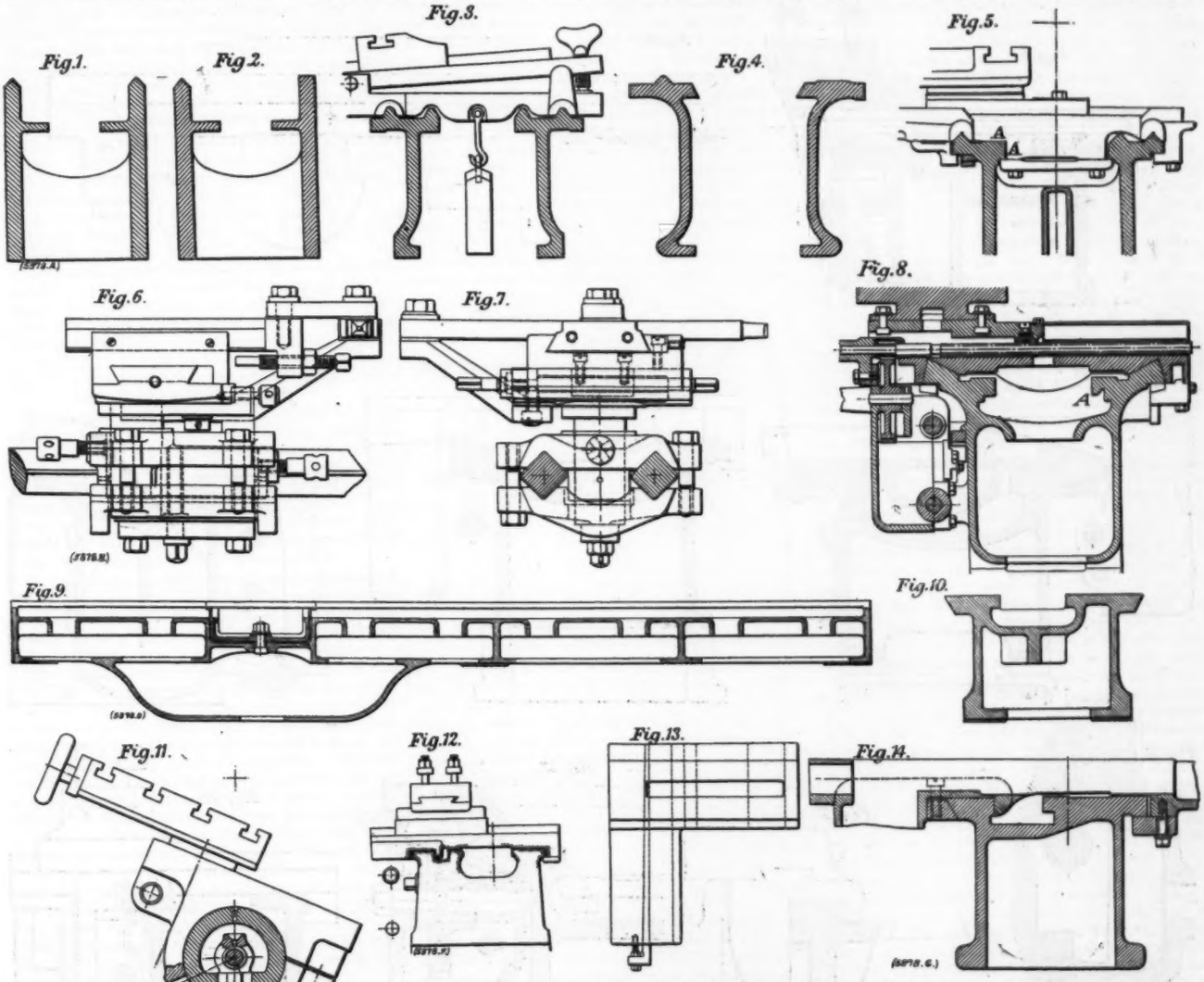
The constantly increasing stresses that are imposed on lathes are reflected in successive designs. The earliest beds were of wood, on which at one stage metal ways were screwed. These were followed by skeleton structures of cast iron, having vee'd ways, Fig. 1, or with a vee and a flat combined, Fig. 2. One of the writer's earliest recollections was that of the throwing out of several lathes of this kind to scrap, to the regret of some sexagenarian turners. Although they were of from 10 in. to 12 in. centres, the headstock pulleys were grooved, and driven with ropes. The lathes that took their place were stout Manchester tools with flat upper ways, and vee'd guiding edges at both back and front, which is still regarded as the common standard English pattern. These projecting edges are the equivalent of the top flange of a beam. The analogue of the bottom flange is the fillet cast along the bottom of each web on the outside or inside, or on both. Increased stiffness is secured by the inclusion of cross-girts, or transverse ribs, adopted in all beds now. These were not present in the earliest beds, the sides of which were cast as separate pieces, and bolted together with cross pieces at the ends. Numbers of the earlier American beds when cast in one piece were without cross girts;—those in which the carriage of the slide rest was held down on the ways with a suspended weight, Fig. 3. The absence of ties away from the ends explains the spreading moulded sections imparted to many of these beds, often greater than those shown in Figs. 3 and 4, a pattern which is not retained when cross ties are included. The suspended weight design has fallen into disuse. Cross girts in the smaller beds are single webs, but in the heavier designs they are now always of hollow boxed section, as they are in the beds of planing machines. They have to be sunk some distance below the ways in order to permit of the passage of the clamp plates of loose poppet and slide rest.

Vees v. Flat Ways.—The explanation of the adoption of the vee section of ways carries us back to the period before planing machines were invented. It was much easier to chip and file vees than wide flat ways. Yet they survive long after the reason for their adoption ceased. Much argument has been advanced in explanation of their superiority, real or supposed, to the flat shears. And indeed the vee'd guides cannot be summarily dismissed because they do not represent standard English practice. They are retained on cylindrical grinders. They are, and always have been, nearly universally employed on planers, where the loads on the tables are greater than they are on lathe beds. A point in favour of their retention is that usually four vees are provided, Fig. 3, the outer pairs for the carriage the inner for the loose poppet. Thus the wear is distributed. Though much can be adduced in their favour, yet there is a tendency for the carriage to slide up off the hinder vee when heavy cutting is being done. The combination of a flat and a vee on one bed is very common, Fig. 4, which also is three generations old, Fig. 2. The question now of course is never one of facility for tooling, but it is of another character. The matter concerned is the retention of the alignment of the loose poppet and the slide rest carriage when the ways wear. Here the vee has the advantage over the flat, otherwise it would not be retained in cylindrical grinders where a very slight departure from parallelism of movement would be fatal to good results.

Loss of Alignment.—When vees wear, the lateral alignment is not affected, but the height of centres only. The first affects the turning of parallel work, the latter has no appreciable results. If the outer vee'd guiding edges of the English flat topped bed wear, the taking-up of the loose vee strip pulls the saddle over. When the inside square edges of the shears, and the tongues on the poppet base wear the alignment of the poppet is lost. With regard to the wear of the broad flat faces, it is contended that vees being much narrower wear more rapidly than these do. There is not so much in this argument as appears, because the cuttings fall away from off vees, while they lodge on flat surfaces, and increase the friction and wear between the ways and the moving parts. Moreover vees need not be made so narrow as formerly, but may be of reasonable width or of modified sections as shown in subsequent illustrations. The objection is often met by the employment of a vee and a wide flat on the same bed. Although the claim is made on behalf of flat ways that wear is long delayed, yet it is well known that they lose their accuracy locally. When a lathe is used mainly for short lengths of

travel of the rest the bed becomes scored and worn on the section adjacent to the fast head.

The retention of flat ways with bevelled guiding edges has introduced the device of the inverted vee to secure permanent alignment for the loose poppet. An example is shown in Fig 8 at A. No attempt is then made to keep the poppet centrally with the bed, but permanently against the vertical edge of the shear above the vee. The clamp plate fits the vee, and the act of tightening it pulls the tongue of the poppet up against the square edge. A rather large number of beds have this fitting. Old turners often have a knack of keeping the ordinarily fitting



poppet always in contact with the vertical edge of one shear after wear has developed, with the resulting slop fit.

Beds are often made with a bevelled guiding edge at the front, and a square edge at the back the better to resist a tendency of the saddle to lift and bind there under heavy cutting.

In the later Lodge and Shipley design, Fig. 5, the carriage fits on two vees, one at front and one at back. In addition, a solid support is afforded by two flat scraped surfaces, A, A, horizontal and vertical on the front shear, directly in the line of pressure of the cut. The carriage is also gibbed on inside and outside square edges. The cross-girts are of box form, and a wide rib of box section goes down the centre of the bed to stiffen it, but primarily to carry rack teeth with which a pawl, pivoted below the tail-stock engages, in order to prevent slip of the poppet when heavy high-speed work is being done. The firm chills the ways of these beds, in order that being much harder than the carriage which is not chilled, nearly all wear comes on the latter. The alignment therefore will be preserved even though the carriage wears.

Triangular Ways.—The very old bed of triangular section due to Maudslay was, like the vee'd ways, adopted in the pre-planing machine days and for the same reasons. It survives now in some small lathes, in the Pittler bed, of a truncated section, and essentially in the square bar beds of some French screw threading machines, hand-operated, Figs. 6 and 7. The bars are of hardened steel, and ground. The slide rest is seen in section, and in longitudinal view. The Pittler bed combines the movement along the axis of the bed with that of the saddle around the axis, so rendering it a universal tool. To give the circular adjustments the trapezoidal form is embraced by a sliding carriage with a cylindrical exterior which is embraced by the saddle of the slide rest.

In the new bed of the Conradson lathes, Fig. 8, the section of the ways is a modified vee at front and back, which may be regarded as a variant of the triangular form. The inner angles furnish larger bearing surfaces than the usual vees, of equal angles do. The outer angles compensate for wear on the inner faces. The bed has a boxed section, adopted for resisting torsional and vibratory stresses Openings are left for chips. The inverted vee, A, will be noticed below the back shear. The loose poppet travels on the inner flat ways, and is tightened and aligned against the vee.

Stiffness.—The stiffness of beds to resist torsional and vibratory stresses has been the cause of several departures from standard types. Usually it takes the form of plating, forming a more or less closed box section, often combined with increased width. The double girder design is another variation. The circular section is another, which is only adopted to a limited extent. Plating greatly increases rigidity, but it is necessary to leave openings for the cuttings, as in Fig. 8, which receive compensation in the curvatures imparted. Many beds include provisions of this general character.

The bed, Figs. 9 and 10, a G. Richards design, of many years since, is plated over beneath the shears, leaving openings for the chips, the openings being reinforced by the bosses, which are connected by a deep longitudinal rib. The bottom of the bed has wide internal flanges, and broad transverse flanges, to the ribs. The gap, and the metal beneath it, are plated.

An increase in the width of the bed section is noticeable in later practice. Old designs were generally too narrow, and therefore ill-calculated to resist the stresses of cutting on the larger diameters when these came beyond the front shear, as in much face-turning, and that swung in the gap. Increasing the width over the bed is more efficient than merely thickening metal in the webs. When increased width is associated with a boxed section, or with a double tier, very heavy cutting can be done.

Stiffness is obtained in another way, with or without the combination with the plated top, in the double girder design employed only for the heaviest beds of all. These depart in other respects from the standard forms. Separate ways, or distinct

beds are used for heads and rests. Double cutting is usual.

Positions of Lead Screw and Feed Shaft.—The section of a lathe bed is influenced by the positions of the lead screw, and the feed shaft. The usual practice has been to dispose the lead screw in front, and the feed shaft at the rear—the "back shaft." Each puts a cross strain, or tendency to twist on the saddle, and neither is afforded protection from falling chips. Each is actuated by separate mechanisms at the rear end of the fast headstock, by methods which it is not necessary to state here, the clasp nut. In a Sellers' design it was disposed snugly in a recess under one shear, where it was entirely protected from chips, and supported along its entire length around half its circumference. Generally now the screw is placed without the bed in front, but it stands out to a less distance than formerly, so reducing the cross-winding effort, and is afforded better protection from chips. The feed shaft is commonly brought round to the front, and below the lead screw, with several advantages that result from their close association.

Though beds of circular cross section have been on a sleeve that goes through a split socket on the saddle, which provides for swivelling the tool round the axis of the stem. A modified cylindrical bed is that used for bench lathes, flat-topped, 4f D section.

Since experiments have proved that the backward thrust of a saddle against the guiding edge is equal to about half the downward force exercised in cutting, it would appear that guiding edges are always made with areas too small to resist the friction imposed on them. If their areas could be made larger, then the amount of take-up with strips would be reduced. While it would be inconvenient

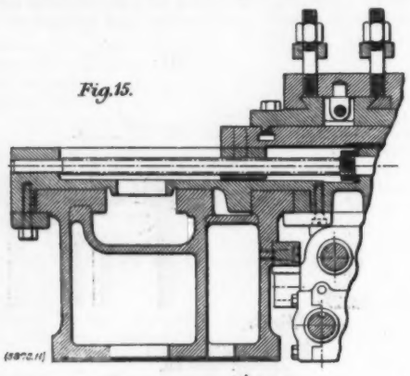


Fig. 15.

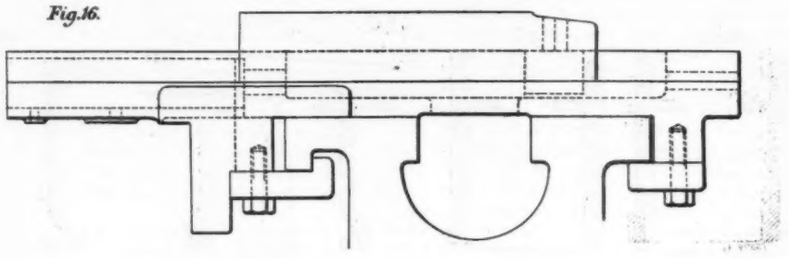
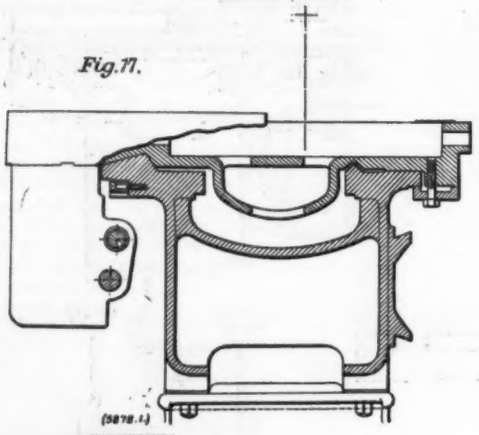


Fig. 16.



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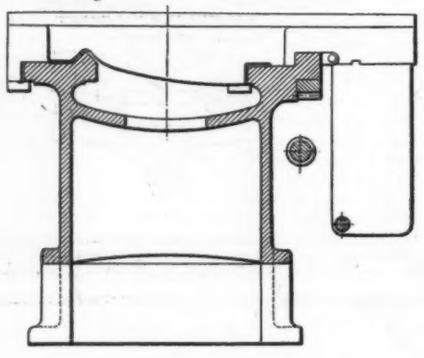

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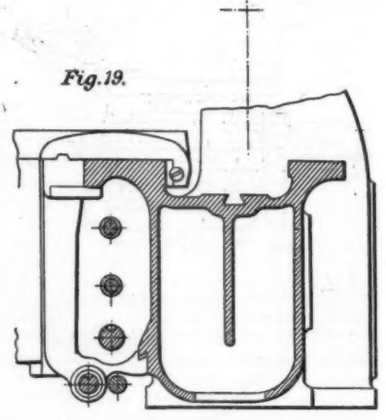

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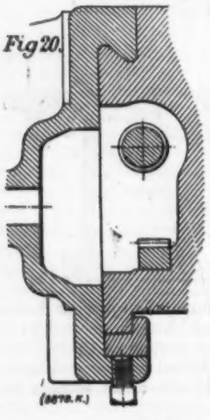

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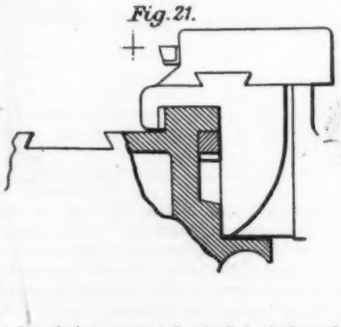

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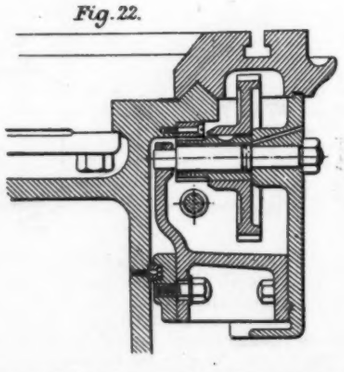


Fig. 22.

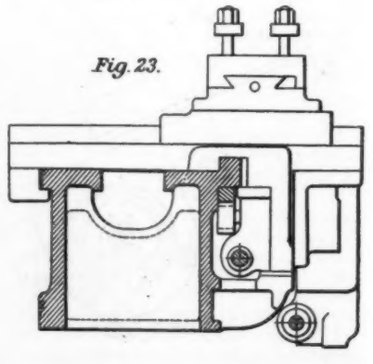


Fig. 23.

since they are being abandoned in present-day designs, to which reference will be made in the proper place. The influence of the position of the lead screw on bed design is the only matter of present interest.

When the screw is placed outside the bed, the shape of the latter is not affected, since brackets attached to the bed carry the screw. But if located within the shears, with a view to get a centralised pull on the carriage, the bed has to be widened to receive the clasp nut. It is interesting to note that the Maudslay double triangular-bar lathe bed had a central lead screw. This was adopted by Whitworth in one design. In later models it was located to one side of the centre, for convenience in operating advocated on the ground that the form is one better qualified to resist torsional stresses than the common forms are, very few firms adopt them. Messrs. Drummond Bros., of Guildford, employ it for a series of small lathes, Fig. 11, and here chiefly to provide means for swivelling the slide rest to different angles, which is of especial convenience in much work done in tool rooms, and by amateurs. The bed is hollow, and is ground outside to receive the saddle. A slot in the under side of the bed receives a bush secured to the bolt that passes up to transmit the motion from the lead screw. The bolt nut tightens the swivelling carriage on the bed, which can be set at any position within the range indicated by the dotted radial lines. The tool rest is carried to encroach on the saddle mechanisms with very deep edges, the desired result is achieved in other ways. Associated with these methods is the question of the cross working or twisting of saddles by the pull of the lead screw or feed rod, and the employment of the narrow guide for the saddle, and of the taking of a portion of the stress that comes on the front shear on a lower tier or auxiliary bed, or on some form of front slide. These various devices are much in evidence in the lathes of the present time, and often in combination, hence they must be considered as related.

The Narrow Guide.—Of late years the practice has developed somewhat extensively of fitting the carriages with a narrow guide on the front shear of

the bed, leaving a clearance on the other side between the carriage and the vertical edge of the shear. The guide usually has square edges, with a take-up in the form of a long wedge strip. That it is a valuable device is a conclusion justified by the fact that it has been adopted and retained after lengthy experience by a good many machine tool makers, not only for lathe saddles, but for the slides of other machines. It seems to have been demonstrated mathematically that the narrow guide has no claim to superiority over the standard saddle that makes contact over the extreme outer ways if the lessening of cross winding effects is considered. But this only regards it as a simple slide where the ratio of length to width is merely increased. The conclusion is that the narrow guide is of value only when length is increased absolutely. But this misses the real reason for its adoption, which is that the pull of the lead screw or of the feed shaft comes directly underneath the narrow guide way, and thus reduces the tendency to cross winding. This is actually a realisation of the old Whitworth central or nearly centrally disposed lead screw.

Figs. 12 and 13 show a narrow guide on the Lang lathes. The take-up strip is seen in plan in Fig. 13, with its adjusting screw and lock nut. The guide is situated nearly over the lead screw and feed shaft. The great length of the guide and the increased width of the bed over that of earlier models is noticeable.

The narrow guide is shown in Fig. 14 as applied to a series of 5 in., 6 in. and 7 in. centre lathes, by Messrs. Drummond Bros., Ltd., of Guildford. The guide includes a square and a vee'd edge, with a take-up vee'd strip located over the lead screw. At the back, a flat gib takes tipping strains only on the gib, a clearance being given between the saddle and the vertical square edge.

The narrow guide, Fig. 15, is embodied in large lathes by Messrs. Smith and Coventry, Limited. It occupies the front shear with a take-up strip in front, and a gib below. Clearance is given on the hinder part of the saddle, which is gibbed to prevent tilting. The saddle is supported well on three broad ways. The poppet slides on the two ways behind the front shear. The bed section is of the boxed form, and has a double girder section.

In Fig. 16 the narrow guide is located underneath the front shear. The advantage gained is that the wearing surfaces of the guide are protected from falling chips. This is by Messrs. Geo. Swift and Sons, Limited.

The Le Blond bed is shown by Fig. 17. It has the front narrow guide exactly over the lead screw and feed shaft. The hinder part of the saddle travels on a flat surface, and is prevented from tilting by a gib. The carriage does not bear on the hinder vee but only on the flat adjacent. The front vee'd shear has two angles. Its front face has an angle of about 15 deg., the hinder one an angle of 70 deg. As the latter wears down the former compensates for the drop of the carriage, keeping a tapered gib in constant adjustment. The bed has a boxed section, being plated right across with a cambered web, and having wide internal flanges on the bottom. The saddle is stiffened with a dished web below, and a flat web above, both being provided with openings to permit chips to fall through. The vee'd ways seen on the hinder face receive the saddle which carries the taper attachment.

Other narrow guides are shown in Figs. 18 and 19, each being directly over the lead screw. In Fig. 18 the saddle bridges the bed. Adjacent to the raised narrow guide there is a flat on which, and on the vee at the rear, the loose poppet slides. The saddle clears each of these ways. It takes a bearing on a flat at the rear to which it is gibbed, and has clearance on the back square vertical edge. The Libby bed in Fig. 19 is a combination of narrow guide to a saddle which does not bridge right across, and of a front support below. The bed section is a box form, plated over the top, nearly closed at the bottom, and having in addition a central longitudinal stiffening rib. This is for a turret lathe.

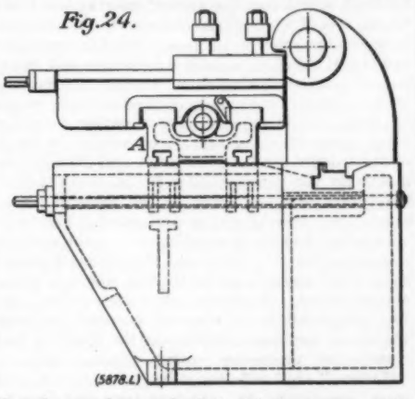
Front Slide Lathes.—The type of these is the bed in which the carriage is supported on a slide in front instead of on the top of the bed. It is old, but though little used by engineers the principle of the front guide has been embodied in such modified forms as that in Fig. 19, and in the double tier bed, and in a design similar to Fig. 19, but worked out differently. But all these differ from the front slide design proper, a feature of which is provision for making vertical adjustments of the tool holder. A bed section of a front slide fitting is shown by Fig. 20. The lead screw lies within, and is protected by the front guides. The saddle fits on a vee above, and on a square way below with a setting up strip.

The Lo Swing lathe is a narrow guide and modified front slide design. The saddle, Fig. 21, does not extend right across the bed, but is carried on the front shear only, which is square with a take-up strip. It also has a bearing against a vertical face below which resists tipping. This lathe is designed for doing heavy bar work, using multiple tools. The tool block therefore fits directly on the saddle, and is solid, the tool being thrust through it, along with its micrometric feed screw. It is therefore a very stable design.

Additional support is afforded to saddles of ordinary forms by the employment of a supporting strip, Fig. 22, let into and screwed into the front of the bed. This not only resists the tendency of the carriage to tilt under heavy cutting but also by reason of the prevention of spring in the apron avoids the chance of separation of the gear teeth. This design is embodied in the heavier Lodge and Shipley lathes.

Double-tier Beds.—The stress of heavy cutting has been the cause of modifications of another character,

Fig. 24.



though sometimes embodied with the narrow guide, that of the double tier bed, and forms that are allied to it, as are those in Figs. 21 and 22, in the fact that they afford support to the apron in the direction of greatest stress, avoiding the unsupported overhang which puts severe torsional stress on the bed and produces chatter. The Darling and Sellers raised narrow guide immediately above the lead screw is shown by Fig. 23, with adjusting strips in front and below. It is associated with the auxiliary or lower tier bed cast with the main bed, and projecting out along the front. This combines the advantage of an ordinary saddle with the support afforded by a front slide beneath the tool. The effectual width of the bed is not that measured over the shears, but includes the dimension over the auxiliary bed. In one unusual form, the Schaerer, there are two lower tiers of vee section on opposite sides of the bed, and the carriage runs on these, and not on the top of the bed, on which the heads alone fit by a flat and a vee. An advantage is that the lower vee ways coming underneath the top shears are protected from falling chips.

Separate Ways for Heads and Rests.—In this grouping large numbers of lathes are included, in which the ways for the carriage of the slide rest do not lie about the axis for those of the heads, as in many of the illustrations already given, but outside and away from them on beds that are independent of main beds. This design is common in all the heavy lathes. Often too in these rests are employed both in front and rear. Such beds are frequently built up from separate castings bolted together. Almost every massive lathe is a type by itself.

A special design modified from the standard is shown by Fig. 24 by Messrs. Dron and Lawson, of Glasgow. The centre of the loose poppet barrel is brought over from the bed centre to lessen the overhang of the tool, the slide rest for which is carried on the ways of the bed A, which fits on extensions that stand out from the main bed. The bed A can be swivelled on these extensions to do taper turning, and the rest can be moved past the tailstock, as in the front slide rest forms.

THE BRITISH SCIENTIFIC PRODUCTS EXHIBITION.

(*Continued from page* 55.)

IN continuing our comments on the Exhibition at the Central Hall, Westminster, we will in the main adhere to the sectional grouping of the alphabetical order of the exhibitors in the catalogue. It will be understood, however, that we have to notice the various exhibits of one and the same firm together, and that the classification of firms may largely be a matter of expediency. We pass to the section on Mechanical Science, comprising engines, measuring machines, and to a certain extent metallurgy, but have first to mention some aircraft exhibits left over last week.

Mr. A. S. E. Ackermann, B.Sc., of 25, Victoria-street, S.W. 1, shows a model of an airship shed door he has designed and patented. These doors are about 100 ft. square, and weigh much about the same as those of ordinary design, viz., 90 tons, but they have the advantage of requiring no concrete blocks to prevent them from blowing over when open, and they also enable a row of sheds to be built in contact with each other. The latter feature thus avoids the necessity for the lean-to's usually employed to take the thrust of the roof, except in the cases of the end sheds of a row. When open, the Ackermann door lies in a shallow pit with its upper surface (which is outside the shed when the door is closed) flush with the surface of the ground. The airship, attached to a cradle, is drawn out of the shed on a railway track, which is continued from the shed, over the door, and on the ground beyond. The end of the door nearest the shed is provided with a wheel on each edge, running in a vertical groove on the door post, and the other end of the door rests on two flanged wheels which run on rails fixed to the bottom of the pit. Wire ropes are attached to the lower surface of the door on each side, one to a point about one-third of the distance from the end nearest the shed and the other to a point at the outer end near the flanged wheels. The first mentioned rope is brought along under the door, up over the edge to a pulley fixed at the top of the door post, and down again to a winding drum inside the shed at a considerable distance from the door. The other rope is brought along under the door into the shed in a practically horizontal direction and joined on to the first mentioned rope at some point between the winding drum and the door; the arrangements are exactly similar on each side of the door. It will be understood that when the winding drum is operated the outer end of the door will be drawn horizontally along the rails in the pit and the inner end will at the same time be raised vertically in the guides in the door posts until the door eventually assumes a vertical position and completely closes the end of the shed. The winding drums are operated by an electric motor of 20 h.p., and the time taken to close the door is 10 minutes. When counterweights are used the maximum tension on each of the two main ropes is 6 tons. The junction of the two ropes, it may be added, adjusts its position so that the pulls on the top and bottom ropes vary in accordance with the position of the door, and it should also be mentioned that the rails on which the door rests in the bottom of the pit are given a slight downward inclination, at the shed end, in order to facilitate the first movement of the door when being opened.

Celluloid Printers, Limited, of Hanway Place, Oxford Street, W., show a variety of protractors for military and drawing office use, in which the figures and division marks are particularly sharp and clear. The marks are etched into the surface and filled with black, or coloured, pigments, which cannot easily be rubbed off. This exhibit includes a course and distance calculator provided with the Appleyard time and distance

dial, which is used for aeronautical work, and, we understand, has been supplied in large numbers to the Air Ministry. By its aid all problems depending upon the triangle of velocities can be solved. For instance, given the air speed and course steered, together with the wind velocity and direction, it is possible to find the direction and speed of the aeroplane relatively to the ground. It is also possible to find the course to steer, allowing for the effect of the wind, when it is required to travel in any particular direction. The instrument consists of a 7-in. disc of white celluloid and another slightly smaller disc of transparent celluloid mounted concentrically, so that one can be turned relatively to the other. The white disc has an engraved compass card, and the transparent disc is divided into small squares. Two radial arms of metal fitted with sliding cursors, and divided for marking the speeds, are mounted at the centre of the discs. These two arms are set in the given directions, and the speeds are set by the cursors. The resultant velocity and direction can then be read off by turning the transparent disc so that one set of lines forming the squares connects the two cursors on the radial arms. An arrow on this disc then gives the direction on the compass card, and the speed is obtained by counting the number of squares between the cursors. A proportion sum must, of course, be worked to find the time required to travel a given distance, or to find the distance covered in a given time, and for this purpose logarithmic scales are provided on the edges of the two discs. These scales can, of course, be used for other arithmetical work. A somewhat more elaborate instrument, similar in principle to that above described, is also shown. It is 11 in. in diameter and is provided with an additional pair of discs instead of the radial arms. This enables smaller wind speeds to be set than is possible with the radial arms since a considerable portion of the latter, near the centre, cannot be used. In place of the cursors two brass fittings are provided, which slide round the upturned edges of the discs, and carry a fine cord wound on spring drums to keep it taut. The wind and machine directions are set by turning the discs, and the velocities are marked by setting the cord so that it cuts arrows engraved on the discs at the required lengths. The direction and length of the resultant is obtained in a similar manner to that described above in connection with the smaller instrument.

Messrs. G. E. Mortley & Co., of Tunbridge Wells, show one of their wind-driven electric generators for use on aircraft. The machine exhibited, which is enclosed in a true stream-line casing, is intended for use with wireless apparatus on the continuous-wave system. and may be arranged to give an output of 100 milli-amperes at 1,500 volts for long range telegraphy, or an alternative system of winding may be provided to give the same current at 600 volts for wireless telephony, together with sufficient low-tension current, at 12 volts, to supply two electrically-heated suits. A centrifugal governor is provided to control the speed of the armature, and so maintain a constant high-tension voltage, and also to protect against overload and consequent burning out in the event of a nose dive. Some device of this kind is essential, as under such conditions the speed of the air screw may become very high. In the case of a generator supplying high tension and heating current simultaneously, compensating fields are used to prevent fluctuations in the heating load from affecting the high-tension voltage. Another useful feature of this machine is that it may be used as a rotary transformer for supplying the wireless apparatus after the aeroplane has landed, the airscrew being automatically disconnected from the armature under these conditions. Messrs. Mortley a'so show a complete dynamo lighting set for use on motor cycles.

One of the first exhibits seen on entering the building is what is called the "A.B.C. Skootamota," shown by Messrs. Gilbert Campling, Limited, of 1, Albemarle-street, W. 1. Its somewhat fantastic name is really well chosen as the vehicle, which is described as a handy run-about of light weight, occupies a position between an ordinary motor cycle and a child's toy "scooter." It is in fact a development of the latter appliance, and is intended more for comparatively short journeys than as a serious touring proposition. Whether or not it will become sufficiently popular to justify its existence, of course, remains to be seen. The machine comprises a steel tube frame, carrying a wooden platform about 6 in. from the ground and mounted on two wheels with pneumatic tyres, 16 in. in diameter. The user may stand on the platform and steer the machine by handle bars connected to the front wheel as in an ordinary cycle, but it is thought probable that he would prefer to sit, and a pan saddle is therefore provided for the purpose. The machine is driven by a small single cylinder air-cooled petrol engine, giving 1½ h.p., mounted in a horizontal position directly over the back wheel, together with the oil and petrol tanks. The engine is connected to the driving wheel by a roller chain completely enclosed in an oil bath. The engine controls are fitted on the handle bars, as also is a lever operating a band brake on the front wheel. Another band brake is fitted to the back wheel, and this is worked by a pedal on the platform. The speed range is from 3 to 20 miles per hour, and is varied by controlling the engine only. The weight of the machine is 65 lb., and we are informed that it will travel about 110 miles per gallon of petrol. Mr. G. Bradshaw, the designer of the A.B.C. aeroplane engines, has collaborated with the manufacturers in the design of this novel vehicle which, we understand, has already undergone extensive tests on the road.

The striking metallurgical exhibits of Messrs. Hadfield, Limited, of the East Hecla Works, Sheffield, which face the visitor entering the Exhibition, would at once force the visitor's thoughts back to the war if he should need a reminder. Prominent amongst these is a full size model of the largest armour-piercing shell, produced in the war, 18 in. calibre; it is made of Heclon steel, weighs 1½ tons, and is capable of perforating at point-blank range 41 in. of hard faced armour or 54 in. of unhardened steel; at 10 miles and 20 miles respectively the penetration is 22 in. and 12½ in. of hard faced armour, while at 24 miles a 12 in. armour plate would still be perforated. The 18 in. cylindrical steel block standing close to the shell has stopped several 4 in. shells and exemplifies the excellence of the material, whilst the 6 in. trench howitzer, muzzle-loader, illustrates the destructive side. The other exhibits are of a more peaceful character. There are specimens illustrating the Hadfield-Jack system of producing sound ingots, hardened "Hadura" shell rolls for rolling steel, nickel, gold, brass, aluminium, &c., gyratory jaws and discs for crushers and wearing plates, pins, bushes, &c., of "Era" steel; manganese steel bars of the "Era" and "Hecla" types for aircraft and motors of a tenacity up to 100 tons per square inch, special magnet steels, "Galahad" stainless cutlery, &c. We find also a model of the Fitzalan-square tramway lay-out, Sheffield, and a crossing and rail taken from that junction which was replaced this year after twelve years' service. The metals and alloys displayed in glass cases, the specimens showing the various stages of the manufacture of "Heclon" high speed steel, and the pyrometers and other apparatus, charts, slide rules, &c., used in the works, indicate what steel making involves.

The exhibits just mentioned stand by themselves in the Exhibition, as do also those of the Parsons' Marine Steam Turbine Company, of Wallsend-on-Tyne, and the Heaton Works, of Newcastle. These are models and photographs of the Turbinia, the first vessel fitted with Parsons' turbine only—one hardly realises it—in 1894, and of the interior of an engine-room of a two-shaft arrangement of geared turbines, a working model showing such an installation driving a cotton mill, and an actual pinion explaining the design of the teeth of geared turbine installations. The parabolic glass reflectors, fitted with Parsons' patent lead and glassware backings up to 120 cm. diameter and 52 cm. focus, were mentioned last year.

The oil engines of Messrs. W. H. Allen, Son & Co., of Bedford, are of excellent design. The specimen shown is a two-cylinder (5 in. by 6½ in.) paraffin-driven engine coupled direct to a 6 in. salvage-pump, capable of delivering 700 gallons of water per hour against a head of 30 ft.

The Carey variable-capacity pumps of Variable Pumps and Motors, Limited, 222, Great Dover-street, S.E. 1, embody very interesting novelties of the last two years, both in pump design and in power transmission. The pump practically contains only one moving part; it serves for working hydraulic machines operated by a ram, such as lifts, cranes, steering apparatus, testing machines, tanks and tractors and aeroplane controls, and the diagrams displayed show how this is done. The "Carey" pump will also run as a motor set; two pumps are coupled together with a simple pipe connection, the one with variable capacity acting as a pump, the other with fixed stroke forming the motor, and the combination forms an effective variable speed transmission such that the forward, backward and brake motions can be controlled by a single lever. The transmission pump working in the Exhibition at pressures up to 3,000 lb. per square inch is driven by a 4 h.p. electric motor, and the oil is returned to a tank. The chief feature in the design of Mr. R. F. Carey is the revolving rotor, a cylindrical steel block which is provided with a number (five or three) of recesses or cylinders, each containing a ball piston and communicating with the two parts of the flat valve at the end of the rotor shaft through a passage drilled parallel to the rotor axis. When the rotor turns, the balls are forced outward (at right angles to the rotor axis) by centrifugal force, but they are kept in by a ring bearing or roller path (the stroke-control ring) which encircles the shaft; the outward centrifugal motion constitutes the suction stroke, the constraining face of the ring imparts the inward or pressure stroke. The position of the control ring can be altered by the aid of a screw at the top of the pump, so as to be either concentric with the rotor axis or eccentric to it. In the neutral concentric position the balls will simply revolve round in the ring without causing reciprocating motion. When the ring is screwed down into its lowest position the lowest of the five balls will be at its maximum outward position (the other balls being nearer in), and when the pump is driven clockwise the right hand side of the pump will be the suction side and the left-hand side the pressure side; by screwing the ring up to its highest position this relation and the flow of liquid will be reversed. The amount pumped can be varied by altering the position of the control ring. For permanent delivery in one direction the control ring is locked in the respective position; in order to vary the capacity either in one or in both directions, the ring is adjusted by a hand wheel or lever. The machines can be belt-driven and be run at high speeds.

Our comments on the petrol engines of the Record Engineering Company, of Burton-on-Trent; on the William-Janney Pump (which we described some time ago), and other exhibits of Messrs. Vickers, Ltd.; and on the pumps and cranes of Messrs. Stothert & Pitt, of Bath, must be held over.

The trolley head of Messrs. H. Royds Tidswell and S. K. Kirkland, of Alvaston, Derby, facilitates the bringing back into contact of the trolley head when it has left the wire by means of an internal spring, a pin and stem and inclined planes. The spring placed in the base of the bracket boss presses the harp stem upward; during this movement the guiding pin on the stem acting on the inclined planes rotates the harp stem back to the pre-arranged position where it remains locked until brought into contact with the trolley wire. When the wheel is placed under the wire, reaction takes place and the wheel and harp descend to their normal position in which the stem is free to rotate unrestrictedly. All the working parts are internal, and the device is weather-proof. The variable-pitch propeller of the same firm is only shown in diagram; the centrifugal forces generated by weights free to slide longitudinally in the blades are changed in direction so as to produce turning moments round the axes of the blades, acting against springs contained in the hub. The pitch is controlled by the engine speed, and the pilot sees the actual blade angle on an electric indicator.

The Vaughan Electric Block of the Vaughan Crane Company, Openshaw, Manchester, is a hoist designed to supplant hand-power pulley blocks for loads from ½ ton up to 4½ tons on continuous or

phase-current circuits. When the block is to travel on a track joist, the one motor can alternately be used for lifting and traversing. The block is fitted with an automatic clip-brake, and the runner wheels are supplied with ball-bearings.

A simple mechanical device for the automatic, intermittent or periodical advance of flexible bands between rollers is shown by Mr. Harvey J. Mills, 9, Park-road, Beckenham, Kent, as applied to calendars and date boxes. The paper tape, with the calendar for the year printed on it, passes over a spiked roller and fastens on to a spring barrel which, being wound up, holds it in tension. The roller is operated by a ratchet and pawl movement and governed by a lever which, when depressed, permits an escapement of the exact length of tape required for each day's showing. The operation may be by pressing a button or better by clockwork mechanism. The device is applicable also to camera and lantern films, indicators (train arrivals and departures), pillar-box announcements, advertisement display, &c.

The Hayter patent cam-lever of Messrs. Hayter, 7, Katherine-street, Croydon, is a simple joint for parts of any construction which should be readily accessible and detachable. For attaching, *e.g.*, a table board to its leg, a screw bolt is used which is fitted above with a pivoted cam lever; it is a blade of steel or brass, the cam of which makes the lever snap and hold tight when turned after the fashion of the blade of a penknife. The device which is supplied in various styles, is convenient for fastening windows, making collapsible boxes, fixing up rails, tents, &c., without special tools. The multiplane for wood of Mr. E. Howkins, 40, Waldemar Avenue Mansions, Fulham, S.W. 6, is another compact handy tool, which by changing the cutters and fences can be used for grooving, dovetailing, jointing, T-slotting, &c.

Mr. A. E. Parnacott, of Penge-lane, S.E. 20, shows several simple novelties. The sparking machine for testing plugs was designed at the request of the R.A.F. to make sure that plugs will spark also when the air is under compression up to 150 lb. per square inch. The plug is watched while the pressure is raised by a pump. The leak detector indicates during this operation whether or not the plug is gastight; leaking plugs are apt to overheat and to become short-circuited by carbon deposit. The detector is a short brass tube, the curved end of which is closed by a window; under the glass a ring-shaped oil film is kept in position by capillary attraction between the glass and a ring underneath it; when a leak takes place, air bubbles are seen to escape through that oil film; the oil oozes back again immediately and remains ready for further use. Inner tyres are tested for leakage in the same way. By lowering such a detector into water of the temperature, at which an oil is to be tested, the detector can serve for rough viscosity tests. Diagrams of a trailer car, for fragile goods, easily charged and emptied and to be hauled from either end, are also displayed. Another speciality of Mr. Parnacott's are drawing instruments, made readily adjustable to any desired feed, irrespective of wear, with the aid of interchangeable needle points and leads.

The typewriter of the Imperial Typewriter Company, of London-street, Leicester, deserves mention because the typebars and keyboards are interchangeable for lettering in various types and for corresponding in more than twenty different languages; special steel type is used.

Fuel Section.—Before passing to the testing and measuring machines we notice the small number of exhibits in the Fuel Section. The first in alphabetical order is Captain T. Fairfield's (of 20, Gloucester-crescent, N.W. 1) hose appliance for transferring liquids (oil) from one vessel to another at sea while steaming at 16 knots in ordinary weather; the appliance, which can also serve for ordinary towing, is only shown in model, and has not been tried yet, but is attracting attention. Mr. Fairfield has taken many oil tank steamer across the seas before and during the war. The indiarubber flexible of the hose is protected by bagging and canvas; the longitudinal towing wires are encircled and held by transverse wires; hose and wires are supplied complete in sections and joined by Admiralty couplings. The ships ahead drops a buoy with ropes attached; the buoy is picked up, and the towed ship pays out the hose through the "compressor" which it carries (a holder of cylindrical shape); as soon as the hose is made fast on the ship ahead, the ship astern falls back. The applications of pulverised fuels, which were recently discussed by the Institution of Civil Engineers in connection with a paper read by Mr. L. C. Harvey, of 25, Victoria-street, S.W. 1, are explained by Mr. Harvey with the aid of samples and diagrams. The Gas Light and Coke Company, Westminster, demonstrates in an artistic kitchen how gas should be utilised scientifically and economically.

The Geological Survey and Museum, of Jermyn-street, S.W. 1, has a large collection of instructive photographs, diagrams and samples on view, the chief mineral products represented being mineral oils, shales, cannel coal, bitumen, &c.; iron ores from the Raasay Field, probably the largest unexhausted source of iron in Scotland; and bauxitic clay from Saltcoats, North Ayrshire, which has proved a very useful high-grade refractory for the manufacture of small electric furnaces and crucibles. The sample of the oil, which rose at Hardstoft on June 3 last, when the top of the carboniferous limestone had been reached at a depth of 3,077 ft., will be examined with special interest; it is pointed out that the estimates of the value of the discovery will largely depend upon the results obtained when the other boreholes in Derbyshire reach the same level as at Hardstoft. Examples of raw materials, crude oils and refined products, from various deposits in Great Britain are also displayed by Mr. J. Arthur Greene and the technical advisers of the committee on the Production of Oil from Coal, &c., upon the report of which we commented in March last.

Two firms show fuel-combustion recorders and cognate apparatus. New, among the well-known "Sarco" apparatus (CO_2 recorders, draught gauges, bomb fuel-calorimeter, gas calorimeter, steam meter, and steam load indicator) of Messrs. Sanders, Rehders and Co., Limited, 108, Fenchurch-street, E.C.3, is a portable CO_2 recorder. The other firm, W. R. Patents, of 8, Old Jewry, E.C.2, prefers to be known by initials only. The W.R. CO_2 indicator is very simple, and differs from the Orsat type in not requiring glass tubes and liquid caustic alkali; the papers offered do not say anything about accuracy tests, but there is a long list of users. An aspirator worked by a small steam jet continuously draws gases from a flue through a filter into a closed chamber, within which a porous cell is mounted; through an opening in the bottom, which is normally screwed down, the cartridge, a cardboard cylinder which is charged with soda-lime, is introduced into the cell. Some of the gases penetrate through the pores of the pot and are absorbed by the soda-lime; a partial vacuum is thereby created, and this vacuum is read off on a gauge of the U type, filled with coloured liquid. The apparatus does not record; the stoker watches the red liquid column in the indicator. The consumption of the injector is said to be equivalent to about one pint of water per hour; when forced draught is used, the injector is not required. The cartridge has to be renewed every 24 hours, and the whole device has to be cleaned once every month by the aid of a water hose or a bucket.

Electrical Appliances.—Electrical apparatus of manifold types are well represented. The Electro-Vapour Radiator, of Messrs. Benham and Sons 66, Wigmore-street, W.1, looks like an ordinary radiator for steam heating, but there is fixed to it, underneath the pipes, a small vapourising chamber, the water of which only requires renewal once every year. This horizontal chamber is closed by a screw-plug, the holder of the heater element which is of the shape of a flat bar of tinned copper, enclosing the resistance wound on a sheet of mica; the loading watts for room capacities ranging from 400 cub. ft. up to 1,200 cub. ft., are said to be 350 watts to 1,100 watts. The firm also exhibits large cooking ranges, built in wrought iron with cast-iron top plate, the electrical parts being heavily insulated. The Benjamin Electric Company, Limited, of Brantwood Works, Tottenham, show their steel reflectors, lanterns, Goliath holders, and the Merrett self-cooker, of the hay-box type.

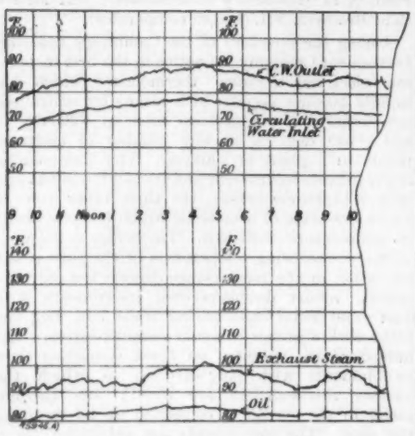
The British Electrical and Allied Manufacturers' Association, of King's House, Kingsway, W.C.2, is very crowded in its group exhibits, several of which are shown in operation. The Association (B.E.A.M.A.) comprises many firms, only some of which we can mention: the Cambridge Scientific Instrument Company; Messrs. Creed and Co.; Messrs. Crompton and Co., of Chelmsford (potentiometers and accessories); Messrs. Elliott Brothers, Limited, Lewisham, S.E. (gyrostats); Messrs. Evershed and Vignoles, of Chiswick (portable testing sets); the Foster Instrument Company, of Letchworth (pyrometers); Mr. Robert W. Paul, N.11. (laboratory instruments); and Messrs. Reid Brothers, N.I. (length comparator).

Among the novelties of the Cambridge Scientific Instrument Company we notice in the first instance the electrical distance thermometer which has rapidly become popular as a means for centralised measurement of temperatures between −200 deg. C. and +540 deg. C. at any number of scattered points in a plant or building. The thermometer is a resistance instrument and its coil forms one arm of a Wheatstone bridge, the three other arms of which are made of a material which has practically no temperature coefficient. The bridge is balanced at the commencing temperature of the scale; any alteration in the temperature deflects the galvanometers, robust double-pivoted instruments with dust-proof metal cases having scales 7 in. long and fitted with a mirror to avoid parallax errors. The indicators are mounted on black enamelled slate switchboards with plug switches to which the various thermometers are wired; any thermometer in the circuit is connected up by inserting the plug. The instruments are calibrated for a standard resistance of the leads of about 2 ohms. One switch on each board is marked "test"; when the plug is inserted in that position, the thermometer is replaced by a resistance of known value; if the deflection then obtained should not be correct, the current can be adjusted. In this way compensation is effected for small changes in the battery voltage. For permanent records the instruments are coupled with the Cambridge thread recorder, in which the pointer is automatically depressed every minute or half minute. These thread recorders may be fitted with two thread frames which dot with inks of different colours and a rocking mechanism which brings the one or other frame alternately under the boom; the mechanism switches in two different thermometers. The double thread recorder has two independent galvanometers; thus four records can be obtained at the same time and with the aid of triple commutators, six records are obtainable. The thermometer itself consists of a coil of platinum wire, wound on a porcelain spool which is usually 50 mm. long and 11 mm. diameter; the coil is dipped into a glaze which protects the platinum, and the whole is protected by some armour, which is a perforated metal sheath in the case of air thermometers, and a steel or copper tube for liquids. The connecting leads are made of lead-covered copper wire; there is one lead to each thermometer with a common return. Our diagram, given on page 76, illustrates a record obtained from a turbine plant at the St. John's Wood power station, London.

The Cambridge high resistance indicators designed for thermocouple work and general measurements are totally suspended, moving coil galvanometers which must be kept free from vibration and be carefully levelled with the aid of three screws and spirit levels. The wall type instrument is provided with a special bracket on which the instrument is kept in position by a hole, slot and plane. With a coil resistance of 70 ohms., the full scale deflection corresponds to $\frac{1}{10}$ milli-ampere, and $\frac{1}{200}$ of this value can be detected; the scale is 7 in. long. The thermometer for aeroplane engine radiators is of an altogether different type. Each instrument has a nickel plated copper bulb about 9 in. long and 11 in. in external diameter, which is immersed in the cooling water and is connected by a flexible capillary tubing to a Bourdon gauge, the pointer of which moves over a dial, 5 in. in diameter, fixed on the dashboard of the aeroplane. The bulb is filled with ether; as the temperature rises, the vapour pressure of the ether

increases, and the pointer of the Bourdon spiral travels over the scale, which occupies three quarters of the dial circumference and is divided in degrees from 50 deg. C. to 100 deg. C. The thermometer responds quickly to changes of temperature in the bulb, but is hardly affected by temperature charges in the connecting tubes. The pointer has, of course to be secured against vibrations of the machine.

The Cambridge workshop potentiometer is designed for the checking of thermocouples in workshop practice and will help to overcome the prejudice of engineers and metallurgists against



RECORD OF TEMPERATURES OBTAINED BY THE CAMBRIDGE SCIENTIFIC INSTRUMENT COMPANY'S ELECTRICAL DISTANCE THERMOMETER.

instruments, the utility of which they are ready to admit, but which they do not altogether trust, not without reason; for thermocouples may go wrong without showing it. The self-contained instrument comprises 2-volt cell, galvanometer and Weston normal cell, &c., all fitting into a portable box; when the lid is closed the accumulator is disconnected. The pointer of the semi-pivoted moving coil is seen beneath the window in the top; the slide wire is wound on a drum and having the great length of 5·5 m. is divided in fractions of a millivolt. We hope to illustrate the instrument, as well as the Einthoven six-string galvanometer, on an early occasion. A laboratory type of this potentiometer is also on view.

(To be continued.)

WORKS AND BUILDINGS, AIR MINISTRY.—Sir John Hunter, K.B.E., Administrator of Works and Buildings, Air Ministry, has tendered his resignation to the Secretary of State for Air; his resignation has been accepted in view of the progress made in clearing up the war work of the Ministry and the desire of Sir John to return to his private business as soon as possible. An intimation of the cordial thanks of the Air Council has been conveyed to him for his eminent services.

ON THE UTILISATION OF STEEL TURNINGS IN THE BLAST-FURNACE.—In conjunction with the article under the above title on page 58 *ante*, the following paragraph, taken from *The Iron Age*, New York, is interesting. According to our American contemporary, Frank H. Crockard, Birmingham, Ala., has been granted a patent (U.S. 1,274,245) covering a method of making pig-iron from scrap steel. In certain territories in the United States, he says, it is impossible to make what is known as Bessemer pig-iron on account of the high content of metalloids, such as phosphorus, carried in the ores. The patentee's invention contemplates the use of all-steel scrap of a suitable character to provide a Bessemer grade of pig-iron, without the addition of any ore to the charge. The blast-furnace is charged entirely with steel scrap, with the requisite percentage of a flux, and with coke. The smelting is then carried on as usual. By the process, a grade of pig-iron is produced which cannot be obtained directly from the use of ores carrying phosphorus in excess of the Bessemer limits. The iron so obtained can be used for many purposes for which high phosphorus irons are not suitable, such as the manufacture of ingot moulds, and as recarburising materials in the manufacture of high carbon steels. This same process, he suggests, can also be used to advantage in producing spiegeleisen. It is claimed that by introducing into the charge of the furnace a small proportion of manganese ore with the scrap, flux and coke, a regular grade of spiegeleisen can be obtained, which it is impossible now to arrive at from ores carrying phosphorus in excess of the Bessemer limits.

THE EXAMINATION OF MATERIALS BY X-RAYS.

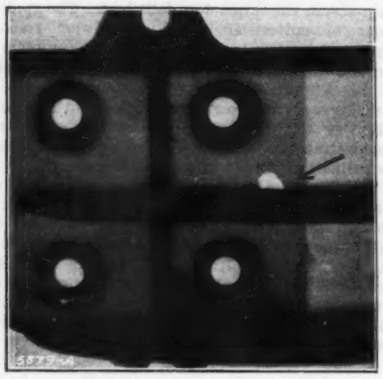


FIG. 1.

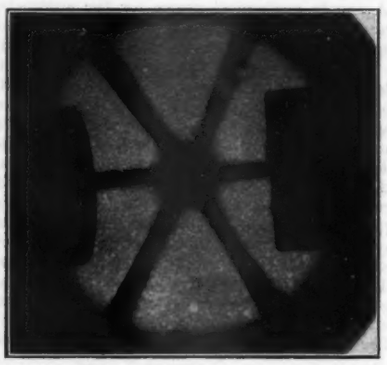


FIG. 2.

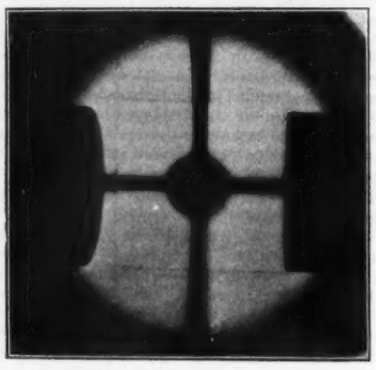


FIG. 3.

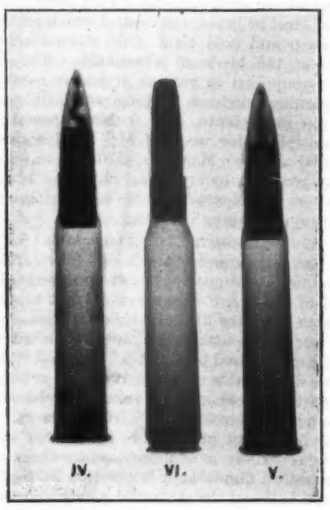


FIG. 4.

IN our articles on "The Examination of Materials by X-Rays," as discussed by the Faraday Society and the Röntgen Society, we referred to some interesting radiographs which Professor Thomas Turner, of Birmingham, exhibited during the discussion on behalf of Major J. Hall-Edwards, R.A.M.C., F.R.S.E., of Birmingham. The last of the three articles appeared in our issue of May 16. The photographs due to Major Hall-Edwards, which we reproduce to-day on this page, reached us too late for that issue.

The first three radiographs of aluminium castings will bring out one of the points to which Major Hall-Edwards wished to draw attention, that mould castings are, on the whole, vastly superior to sand castings. Fig. 1 illustrates portions of a casting for an aero-engine. The large blow-hole which is marked by the arrow, was not discovered until a considerable amount of labour had been expended upon the piece, whilst a radiographic examination would at once have caused the rejection of the casting. Fig. 2 is another sand casting; in this case the innumerable small blow-holes which, on Fig. 1, one might think merely to be photographic imperfections, are more distinct. The rays passed in Fig. 2 through the end of a piston, the metal thickness being ¾ in. The mould casting of Fig. 3, likewise a radiograph through the end of a piston, is decidedly superior; there are no signs of any blow-holes; the fine lines which can be distinguished indicate where the various portions of the mould had been. The three views on Fig. 4 are radiographs of a different nature, taken through loaded cartridges. The end of the bullet is partly filled with some transparent material, possibly aluminium. The figures show an extraordinary distribution of the lead at the points of the bullets, a distribution likely to influence their carrying straight. The right-hand example is the old, round-nosed bullet of the South African War.

NON-FERROUS METALS.—The following are the stocks (exclusive of old metal and scrap) in this country in possession of the Minister of Munitions on the 1st inst.:—Copper, 44,298 tons; spelter, G.O.B., 26,059 tons; spelter, refined, 13,356 tons; aluminium, 10,662 tons; soft pig-lead, 121,135 tons; nickel, 2,452 tons; antimony regulus, 4,368 tons. The quantity of nickel in stock on June 1, 1919, was 2,552 tons, and not 3,552 tons.

SWEDISH PIG-IRON PRODUCTION.—Sweden, in 1897, produced 538,197 tons of pig iron; her production in 1917 was 828,969 tons. Her iron ore output for the same years was 2,086,119 tons and 6,217,172 tons respectively.

AMERICAN BEEHIVE COKE.—Figures issued by the United States Geological Survey show that the production of beehive coke for the week ending June 7, amounts to 269,000 tons, as compared with 264,500 tons for the week ending May 31, and with 660,000 tons for the week ending June 8, 1918. The production of beehive coke this year, to date, is 8,750,000 tons, as compared with 13,207,000 tons for the corresponding period of last year.

NEW ALLOY FOR MILLING CUTTERS AND OTHER TOOLS.—A new high-speed steel, known as chrobaltic alloy which can be cast into intricate shapes, is used, says *The Iron Age*, as a substitute for tungsten and vanadium steel by the Chrobaltic Tool Company, Railway Exchange, Chicago, in the manufacture of milling cutters and other tools having multiple cutting edges, also for blanking, drawing and forming dies, hot and cold trimmers and other shapes. Its resistance to abrasion is said to make it particularly adapted for gauges and other measuring instruments. The cast tools are supplied in a finished state ready for use, or they are supplied in annealed form to the customer, who machines them to accurate dimensions and hardens them for use. The castings are said to be practically non-rusting and acid-resisting, and the heat-resisting qualities of the alloy are such that it does not scale in the fire, thus adapting it to milling cutters having thin edges. The steel may be hardened in oil or air; annealing and re-hardening may be repeated without the steel losing any of it properties. The cutters and tools do not change their shape in hardening. The steel has a comparatively high scrap value, in that the cast cutters can be remelted and used over again. The cutter or tool is cast to practically the finished form, leaving $\frac{1}{32}$ in. to $\frac{1}{16}$ in. for finishing. Final finish is by grinding. Usually, annealing is effected up to 1,832 deg. F. in a closed muffle. Cooling is allowed to proceed slowly.

THE LIMITS OF THERMAL EFFICIENCY IN DIESEL AND OTHER INTERNAL COMBUSTION ENGINES.*

By Sir DUGALD CLERK, K.B.E., D.Sc., F.R.S., M.Inst.C.E.

THE increasing interest of the Government and the general public in the conservation of the fuel resources of the country is highly gratifying to engineers who have devoted their lives to economising heat as used for the production of motive power, but there is some danger of ignorant legislation conceived in the German spirit of "colossal" change which, if unchecked, will lead the country to disappointment and, may be, disaster.

Newcastle and the North-East Coast has long been famous for its success in steam motive power inventions from the time of Stephenson in 1814 to that of your distinguished townsman of to-day, Sir Charles Parsons. Although your main efforts have been devoted to the development of steam power in its varied forms, you have also contributed materially to the success of the great rival of steam—the internal-combustion engine. Mr. James Robson, a Northumberland man, was one of the pioneers of the gas engine, and at a later stage one of your important engineering firms, Messrs. Richardson, Westgarth, Limited, devoted much time, energy and money to the development of large cylinder gas engines. The Diesel engine has also occupied you, and important work on that interesting type has been done in the district, notably by Messrs. Doxford and Co., in producing engines for ship propulsion. The war, which has terminated so successfully for the British Empire and our gallant Allies, has also had a great effect in stimulating the production of engines for flight, and a substantial share in the task of improving the engines has fallen to the North-East Coast district.

Towards the end of the war, nearly 3,000 aircraft engines were produced in Great Britain per month, and a similar number of aeroplanes. In consequence of this, all internal-combustion engines were greatly improved in detail construction, so that the dry weight of those motors was reduced during the four years of strife from above 4 lb. to 2 lb. and lower per brake horse-power developed.

The rival systems of air and water cooling were thoroughly investigated, and air-cooled engines became possible in which the mean effective pressure was raised to equal that of the best water-cooled engines. The high-pressure value, that is the mean pressure equivalent of the brake horse-power developed in water-cooled engines, had risen to about 125 per square inch of piston area by the middle of 1916, and the same high-pressure value was obtained in air-cooled engines at the end of 1917.

The struggle between the rotary and fixed cylinder radial engines was very keen, and recently it appeared probable that the latter would prove so advantageous in both military and mechanical properties as to displace all other types.

In Diesel engines for submarines great advances were made by many engineers both naval and civilian in the use of the so-called solid oil injection and the application of aluminium pistons to the heavy oil engines, as well as to petrol engines for aircraft. Large power gas engines for stationary work were also developed by such firms as Westinghouse and the National Gas Engine Company, who designed and built tandem vertical engines of the four-stroke type, the largest having six cranks and twelve cylinders running at 200 r.p.m. and giving over 1,500 brake horse-power per engine. Of these about 200,000 h.p. are now in use, many of the engines being applied to factories for producing war material.

In aircraft engines super-compression by air and exhaust gases has been applied to increase the power of the engines at great heights and engines such as the Napier "Lion" have been built with lightly designed large cylinders which are throttled down at or near ground level, and opened up automatically as the height increases. According to a trial, of which a report was published in the Press, the great altitude of 30,000 ft. has been attained by one of those engines in a flight from Martlesham Aerodrome.

In view of all the developments, the internal combustion engines now in existence in the United Kingdom could develop in all about 2,000,000 brake horse-power exclusive of the engines used for flight.

Considering the rapidly growing importance of gas and liquid fuel in our country for stationary engines, driving factories and generating electricity, it is desirable to discuss the present position and the future possibilities of obtaining motive power by such fuel in the most effective manner. That is, in such manner as to transform the largest proportion of the heat value of the fuel into brake or to electrical horse-power.

The relative position of steam engines and internal combustion engines was fully considered in the year 1882 in a paper by me on "The Theory of the Gas Engine,"† and by others in the discussion which followed. At that time the highest thermal efficiency given by a steam engine was found in the account of an engine trial at Blackburn published by Mr. Michael Longridge, M.Inst.C.E. The thermal efficiency of this steam engine was 12·7 per cent. of the total heat of the steam used. Assuming a boiler efficiency of 80 per cent. this gave an indicated efficiency of 10·2 per cent. referred to the total heat of the coal consumed in the boiler furnace and at 90 per cent. mechanical efficiency it gave 9·2 per cent. brake thermal efficiency. At the same time a test by Messrs. Bryan Donkin and Co. was given as 9·2 per cent. heat of steam to indicated work, or 6·6 per cent. from coal to brake power of the engine.

At this date the brake thermal efficiency of the compression gas engines, referred to the total heat of the gas, was 14 per cent. as shown in trials by Dr. Slaby, Professor Thurston and Mr. Garrett for the four-stroke engines of Otto type and the Clerk two-stroke engines.

In 1882 it was very generally assumed by engineers that the steam engine had reached its highest development so far as thermal economy was concerned. This position was accepted by me, and indeed. Professor Kennedy (now Sir Alexander) stated in the discussion :—

"The theoretical efficiency of a steam engine could not be greatly increased because of the rapid rise of pressure with temperature in the fluid used, while the gas engine had the great advantage that a very high temperature could be obtained in it with only comparatively moderate pressures. The theoretical maximum of such engines as the Otto (silent) or Mr. Clerk's, was about 80 per cent. or 85 per cent., *i.e.*, a perfect gas engine working between the same temperatures would convert into work that proportion of its whole heat of combustion."

We were mistaken : the steam engine by the use of triple expansion in cylinder engines and the steam turbine by the use of numerous expansions and intensified vacuum utilised the available temperature range to such an extent that about the year 1914 the large steam turbine gave the indicated equivalent of 23 per cent. thermal efficiency referred to steam heat and 19·5 per cent. referred to brake horse-power. This is about 16.6 per cent. brake thermal efficiency calculated on the fuel fed to the boiler furnace.

Meantime the internal combustion engine efficiencies had been raised to 35 per cent. and 37 per cent. indicated, and about 30 per cent. and 33 per cent. brake efficiency.

Considering both steam and internal-combustion engines as apart from the boiler or the means of gas production, as mechanisms converting the heat in the working fluid into indicated work, gives the steam efficiency as 23 per cent., and the gas efficiency as 35 per cent. to 37 per cent. But when the boiler is included the steam indicated efficiency falls to 19·6, and when the gas producer efficiency of 85 per cent. is included the gas engine indicated efficiency falls to between 29·8 per cent. and 31.4 per cent., and the brake efficiencies to between 26·8 per cent. and 28·4 per cent.

The following table shows the comparison :—

Steam and Internal-Combustion Engine Thermal Efficiences in 1882 *and* 1914.

	Steam Engines.		Internal-Combustion Engines.	
	Thermal Efficiency to Heat of Steam supplied to Engines.		Thermal Efficiency to Heat of Gas supplied to Engines.	
Year.	Indicated.	Brake M.E. 90 per cent.	Indicated.	Brake M.E. 90 per cent.
	per cent.	per cent.	per cent.	per cent.
1882	12·7	11·4	16·0	14·0
1914	23·0	19·5	37·0	33·4
	Thermal Efficiency to Heat of Coal supplied to Boiler. Boiler Efficiency, 85 per Cent.		Thermal Efficiency to Heat of Fuel supplied to Gas Producer. Gas Producer Efficiency, 85 per Cent.	
	per cent.	per cent.	per cent.	per cent.
1882	10·8	9·7	13·6	11·9
1914	19·6	16·6	31·4	28·4

Thus the brake thermal efficiency obtained from coal burned in the steam boiler furnace in the best steam engine test up to the year 1882 was 9·7 per cent., while the best internal combustion engines of that period gave a brake thermal efficiency of 11·9 calculated from the heat of the coal used in the gas producer.

By the genius and perseverance of the Hon. Sir Charles Parsons the steam turbine was so developed from 1884 to 1914 that in the latter year the best steam turbine efficiencies referred to coal consumed in the furnace had risen to 16·6 per cent. Meantime the corresponding value of gas engine efficiency had risen to 28·4 per cent. All engineers were surprised at the success of the steam turbine in following the rising thermal efficiencies of the internal combustion engine. Not only did the steam turbine improve on reciprocating steam engines in fuel economy, but it surpassed them to an extraordinary extent in the magnitude of its practicable units so that the enormous power of 50,000 brake horse-power can now be developed on a single rotating shaft. No reciprocating engine, either steam or internal combustion, have been able so far to produce power units of such magnitude, hence in the generation of electricity and the propulsion of high speed naval and other steam vessels the turbine has displaced the reciprocating steam engine on land and sea. The beautiful single-acting central valve steam engine of Willans and double-acting high speed steam engines such as that of Bellias and Morcum have ceased to compete with the turbine.

The large unit internal combustion engine has, however, made considerable progress since the idea of relatively small and numerous cylinders was adopted by the Westinghouse and National Companies, and over 200,000 brake horse-power of those types is now at work in this country in units up to the 6-crank vertical tandem gas engine with 12-cylinder rated 1,500 but developing 2,000 brake horse-power with ease at 200 r.p.m.

The law of similar structures* and the experience of high speed petrol engines for flight all point to ultimate success in the construction of large gas engine units composed of many cylinders geared to a common shaft. I have discussed the principles of such engines with Sir Charles Parsons, and we are agreed that multiple cylinder units of 10,000 brake horse-power on a single shaft are quite capable of practical construction on these lines. It only requires the design and development of a unit cylinder of about 250 brake horse-power capacity at 250 r.p.m. and four 12-cylinder engines of this type could readily produce the required power in one shaft. Large cylinder engines such as had been developed in Germany before the war do not permit of very large unit powers except at an extravagant weight and cost. Such large cylinder engines have no chance of competing with the steam turbine in the production of large units.

At present the reciprocating gas engine is superior in fuel economy to the steam turbine, but it is probable that the large steam turbine may still improve in thermal efficiency. It is much to the benefit of both steam and internal combustion industries that this rivalry should continue to exist the steam turbine engineers attempting to increase thermal efficiency and the internal combustion engineers' power magnitude of unit, and thermal efficiency, simultaneously.

Before discussing the case of the Diesel or the petrol engines I shall consider now the efficiency improvement yet possible in gas engines. To do this it is necessary to refer to some standards of comparison in order to appreciate the margin remaining for heat and power economies. This appears to be the more necessary from some views expressed in the discussion following the reading of Mr. Ricardo's† admirable paper on "High-Speed Internal Combustion Engines" in April of last year.

Mr. E. Hall Brown, a well-known engineer, then stated that—

"He could not agree that the internal combustion engine of any type and least of all the slow speed type, owed anything to its design being on 'sound thermo-dynamic lines.' Sound thermo-dynamics would rule every internal combustion engine of to-day out of court. As a matter of fact, the internal combustion engine of to-day was a wretched compromise made with the deliberate purpose of sailing as close to the wind as possible, while evading the penalty of broken thermo-dynamic laws."

Mr. Hall Brown appears to me to fall into a curious and interesting confusion of thought hardly to be expected from an engineer with his practical experience in internal combustion engine work.

Mr. Hall Brown's expressions must be my excuse for inflicting on you the dissertation on elementary thermo-dynamics which now follows. Speaking seriously, it is impossible to advance in heat engine design and improve further in fuel economy without keeping clearly in mind the main facts of thermo-dynamics which have been developed by Joule, Kelvin and Rankine in our country, and by Carnot, Meyer, Clausius, Helmholtz and Hirn on the Continent.

Motive power engineers are concerned with the two fundamental laws of thermo-dynamics.

The First Law of Thermo-dynamics is :—

Heat and mechanical energy are mutually convertible, and heat requires for its production, and produces by its disappearance, mechanical energy in the proportion of 1,390 ft. lbs. for each centigrade heat unit, a centigrade heat unit being the amount of heat necessary to heat 1 lb. weight of water through 1 deg. C. This is Joule's law first determined by him in 1843.

The Second Law of Thermo-dynamics.

Although heat and work are mutually convertible and in definite and invariable proportions, yet no conceivable heat engine is able to convert all the heat given to it into work.

Apart altogether from practical limitations, a certain portion of the heat to be converted into mechanical work must be passed from the source of heat to a colder mass or body in order to obtain mechanical energy.

To get a continuous supply of mechanical energy depends on getting a continuous supply of heat falling from a higher to a lower temperature. It is by the alternate expansion and contraction of some substance, usually steam, air or products of combustion partly air, that a proportion of heat is converted into mechanical energy.

Perfect heat engines are ideal conceptions of machines which are practically impossible, but whose operations are so arranged that, if possible, they would convert the greatest conceivable proportion of the heat given to them into mechanical work.

Sadi Carnot conceived the idea of a perfect heat engine cycle of operations, and it was modified later by Rankine and Clausius into the form which is consistent with Joule's discovery of the mechanical equivalent of heat. For the purpose of the demonstration two things only are assumed (*a*) that if heat be added to any body under standard conditions of temperature, pressure, and volume, and the body be carried through any series of mechanical processes, returning ultimately to the standard conditions of temperature, pressure and volume ; then the quantity of heat added to the body is the same as that which has been discharged from it ; (*b*) that no process exists whereby a given mechanical energy can increase its own quantity.

On these indisputable assumptions is based what is

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* Paper read before the North-East Coast Institution of Engineers and Shipbuilders, 1919.

† "The Theory of the Gas Engine," by Dugald Clerk. *Proc. Inst. C.E.*, vol. lxix, Session 1881–82, Part iii.

* See Appendix A, "On Variation of Engine Weight with increasing Dimensions."

† "High-Speed Internal-Combustion Engines," by Harry R. Ricardo, B.A. North-East Coast Institution of Engineers and Shipbuilders, April 30, 1918.

now known as the Carnot cycle, which consists of four simple and easily imagined operations assumed to occur within a cylinder behind a piston so arranged that during the cycle work can be done by the working substance or fluid upon the piston or work done by the piston on the working substance or fluid.

The four operations are as follows :—

First Operation.—The given volume of the working fluid is supposed to be confined at its highest temperature and pressure in a cylinder behind a working piston, the piston is forced out by the pressure, and the heat is added to the working fluid to keep the temperature constant while the piston moves and the fluid expands doing work upon the piston.

Second Operation.—The supply of heat is cut off, and the working fluid expands also, doing work upon the piston, while the temperature falls to the lowest point and its volume increases to a maximum.

Third Operation.—The piston returns, compressing the working fluid, but allowing the heat of compression to escape, so that the temperature remains during the operation at its lowest.

Fourth Operation.—The piston compresses the working fluid adiabatically till the temperature rises again to its highest point and the operation terminates with the working fluid at the same volume, pressure, and temperature as at the beginning.

The first and third operations are isothermal respectively—expansion and compression at the highest and lowest temperatures. As the second and fourth operations are adiabatic, also respectively expansion and compression between the same limits of temperature, it follows that all the heat is supplied to the cycle on the isothermal expansion and that portion of the heat which is discharged leaves the fluid during the isothermal compression.

These operations would give an indicator diagram with a work area, that is if the series of four operations be supposed to occur within a cylinder having a piston connected to a crank shaft and flywheel, work would be done on the piston which would be transmitted to the flywheel.

If it be supposed, however, that the processes be reversed so that adiabatic compression raises the temperature from the lowest to the highest and the isothermal compression be conducted at the highest temperature instead of the lowest then on the next out-stroke adiabatic expansion from the highest to the lowest, terminating in isothermal expansion to complete the reversed cycle. In this reversed operation work would be done by the piston on the working fluid. This reversed operation would be performed by exactly the same amount of mechanical energy as was given out in the direct operation of the engine.

An engine which fulfils these conditions will give the greatest amount of work which can be obtained from a given quantity of heat falling through a given temperature range. And it is evident that this must be so, because if we assume the existence of any engine under the same conditions giving a greater amount of work from the same quantity of heat, then that engine could drive a Carnot engine in the reverse direction so as to return in the reversed engine at the highest temperature a greater amount of heat than was abstracted by the direct engine, and so mechanical energy could be obtained without any source of heat supply. This would be contrary to the established universal truth that energy is as incapable of creation or destruction as matter. Energy may change its form indefinitely while passing from a higher to a lower level, but it can neither be created nor destroyed.

This marvellously simple demonstration is obviously independent of the nature of the working fluid ; it applies equally to all working substances whether solid, liquid, or gaseous, whether physical state changes or not. It at once gives a standard to the limit of mechanical power which could conceivably be obtained from a given amount of heat and a given temperature fall.

The idea of an absolute zero of temperature came later than the Carnot cycle and an examination of the physical properties of air by Joule and Thomson in the light of the first and second laws of thermo-dynamics led to the determination of the absolute zero of temperature as − 273 deg. C. From these determinations the second law was given quantitative form.

The thermal efficiency E of a Carnot cycle engine is :

$$E = \frac{T - T^1}{T} \text{ or } 1 - \frac{T^1}{T}$$

where T^1 is the absolute temperature at which heat is supplied and T^1 the absolute temperature at which heat is discharged.

If the lowest available temperature be taken as 17 deg. C. (290 deg. C. abs.) a very usual atmospheric temperature, and combustion be considered as supplying heat at temperatures ranging from 400 deg. C. absolute, then the curve shown at Fig. 1 gives Carnot cycle efficiencies plotted against temperatures rising to 2,500 deg. C. absolute, the Carnot thermal efficiency rises from 0·275 at 400 deg. C. absolute to 0·884 at 2,500 deg. C. The Carnot cycle is impossible in actual engines because of the high maximum pressures and low effective pressures involved in the process.

Fig. 2 has been prepared to demonstrate the diagram which would be produced in an engine using pure air as the working fluid assuming that no heat was passed to or from the enclosing metal walls. The diagram shows the data required to produce in such an engine an indicated thermal efficiency of 0·64 or 64 per cent.

The four operations (1) Isothermal expansion, (2) adiabatic expansion, (3) isothermal compression, (4) adiabatic compression.

This ideal indicator diagram, assumes that at the fourth operation the volume of the air behind the piston is 1 cub. ft., its temperature 290 deg. C. abs., and its pressure atmospheric 14·7 lbs. per sq. in. The adiabatic compression is continued till the pressure of compression rises to 500 lb. per square inch and the temperature is then 806 deg. C. abs., while the volume is reduced to $\frac{1}{12 \cdot 24}$ cub. ft. To complete the cycle it is necessary to expand during operations 1 and 2 to 2·5 cub. ft. volume. The isothermal compression in the third operation is carried from 2·5 cub. ft. to 1 cub. ft. at which the fourth operation begins.

It will be seen that although the maximum pressure is 500 lb. per square inch absolute, the work area gives only 6 lb. mean pressure per square inch. Such an engine is impossible as a practical machine, but nevertheless the Carnot cycle is of great value to the engineer as an ultimate standard.

Obviously it is necessary to find some other cycles of operation which, although they give lower thermal efficiencies, are of a practically useful nature by giving sufficiently high effective pressures compared with the maximum pressure.

There are two cycles of operation which have reasonably high thermal efficiencies, although imperfect, that is, irreversible ; they are the constant pressure and constant volume cycles. In constant pressure engines the heat which is to furnish motive power is added to the air at constant pressure during expansion. In constant volume engines the heat is added while the piston is at the inner end of its stroke and the volume is practically constant during the heat addition and the pressure rises. In both cases the indicated thermal efficiency can be calculated from the compression ratio and in both cases the same efficiency is obtained with the same compression ratio.

Fig. 3 shows a standard air cycle diagram of a constant pressure engine without heat loss ; adiabatic compression of air is shown from 1 cub. ft. to $\frac{1}{12 \cdot 24}$ cub. ft. the compression ratio $\frac{1}{r} = \frac{1}{12 \cdot 24}$. Heat is added at the constant maximum pressure, 500 lb. absolute in this case, and the temperature rises from 806 deg. C. to 1,973 deg. C. absolute, then adiabatic expansion follows till the pressure falls to that of the atmosphere. This it does in the example when the volume expands to 3·5 cub. ft.

The indicated thermal efficiency is—

$$E = 1 - \left(\frac{1}{r}\right)^{0 \cdot 4} \quad . \quad . \quad . \quad (1)$$

In this case

$$E = 1 - \left(\frac{1}{12 \cdot 24}\right)^{0 \cdot 4} = 0 \cdot 64.$$

Fig. 4 shows a standard air cycle diagram of a constant volume engine in which the maximum pressure and temperature is the same as in Fig. 3, that is maximum pressure 500 lb. absolute and temperature 1,973 deg. C. abs. In this case the compression ratio is $\frac{1}{r} = \frac{1}{5}$ and the efficiency formula is the same $E = 1 - \left(\frac{1}{r}\right)^{0 \cdot 4}$. Here $E = 1 - \left(\frac{1}{5}\right)^{0 \cdot 4} = 0 \cdot 48$. The efficiency is here lower than in the constant pressure diagram, but the expansion terminates at 1 cub. ft. the original volume of the air before compression. The constant volume cycle would give the same efficiency if the compression ratio had been the same $\frac{1}{12 \cdot 24}$ but the maximum pressure would have been much higher. It would have been 1,225 lb. per square inch instead of 500 lb. or 2·45 times as much.

Fig. 5 shows a standard air cycle diagram in which the constant pressure addition of heat is performed just as in Fig. 3, but the expansion is only carried to the volume existing before compression, and the heat is discharged at constant volume instead of constant pressure. Here $\frac{1}{r}$ is the compression ratio as before, but the relative volume at t_c and T requires to be considered ; taking this ratio as ρ :

$$\rho = \frac{t_c}{T} = \frac{V_c}{V_T}.$$

The efficiency formula (1) is then modified to

$$E = 1 - \left(\frac{1}{r}\right)^{\gamma - 1} \cdot \frac{\rho^{\gamma} - 1}{\gamma (\rho - 1)}.$$

Fig. 1.

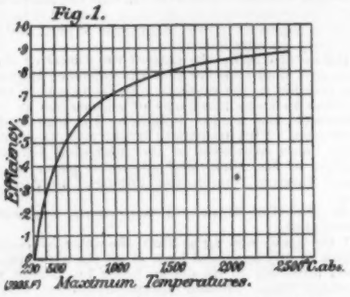


FIG. 1. CARNOT CYCLE EFFICIENCIES. MINIMUM TEMPERATURE 290 DEG. CENT. ABSOLUTE.

Fig. 3.

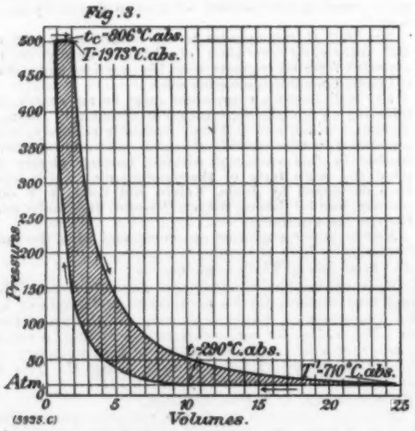


FIG. 3. DIAGRAM OF AIR ENGINE. CONSTANT PRESSURE TYPE.

Fig. 2.

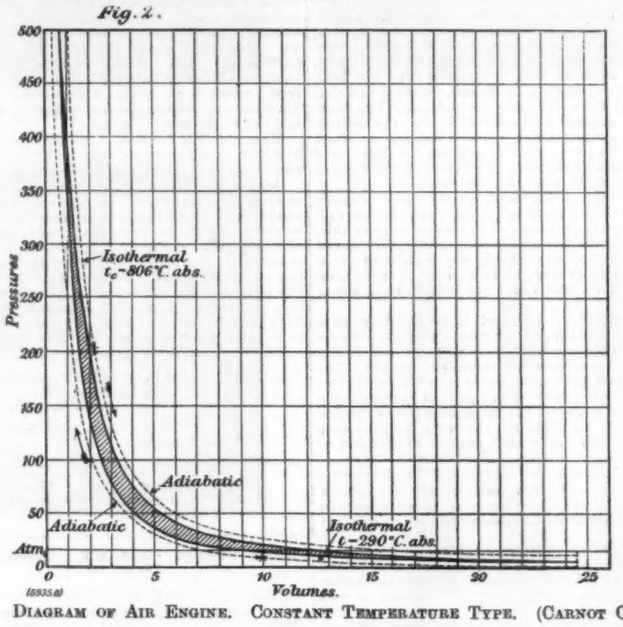


FIG. 2. DIAGRAM OF AIR ENGINE. CONSTANT TEMPERATURE TYPE. (CARNOT CYCLE.)

In this air engine case :

$$E = 1 - \left(\frac{1}{r}\right)^{0.4} \cdot \frac{\rho^{1.4} - 1}{1.4\,(\rho - 1)}$$

With the same compression ratio as in Fig. 3 the efficiency becomes E = 0·56.

It was interesting, and to some engineers and physicists unexpected, to find that the possible thermal efficiency of constant pressure and constant volume engines using air at constant specific heat as the cooling fluid, could be expressed in terms of the relative volume of compression space to total volume of air charge utilised. To some it seemed extraordinary that the efficiency was constant for all temperatures above the temperature of compression. I first discovered this constant thermal efficiency in the constant volume engine expanding to the original volume of the cooling fluid in 1881 during my study of gas engine problems for the purpose of a paper read at the Institution of Civil Engineers in 1882, already mentioned, and I then stated :—

"In an engine of type 3 expanding to the same volume after ignition as before compression, the possible duty D is determined by the absolute atmospheric temperature T^1, and the absolute temperature after compression T ; it is $D = \frac{T - T^1}{T}$ whatever may be the maximum temperature after ignition. Increasing the temperature of ignition increases the power of the engine, but does not cause the conversion of heat into work. With any given maximum temperature the smaller the difference between that temperature and the temperature of compression, the greater is the proportion of added heat converted into work with any given amount of expansion."

At one time cycles of constant efficiency were not understood, and it was even thought that such cycles involved a contradiction to the second law of thermodynamics. Lord Kelvin himself was of this opinion in 1881. I vividly remember a conversation I had with him at the Crown Iron Works, Glasgow, in that year, upon the results I had deduced from tests on my early gas engines. I had then come to the conclusion that the Otto four-stroke and my two-stroke engine operated on a cycle of constant thermal efficiency, and I explained this to Lord Kelvin. He had not studied such cycles, and his view then was that no such cycle could exist, because he thought it was contrary to the second law of thermodynamics. Some idea of this kind was formerly held by many scientific men, and this doubtless prevented the careful investigation of imperfect cycles of different kinds at an earlier stage of the development of the internal-combustion engine. Lord Kelvin only accepted my view as to the constant thermal efficiency of an ideal explosion air engine after I had called his attention to Professor Macquorn Rankine's treatment of the Joule air engine cycle in his work on "The Steam Engine." No constant efficiency formulæ are accepted by all scientific engineers as correct in their application to internal-combustion engines under the ideal conditions already mentioned.

The efficiency formula :

$$E = 1 - \left(\frac{1}{r}\right)^{0.4}$$

is of wide application, and it also determines the particular efficiency from the adiabatic compression also in the case of the Carnot cycle. Here, too, the ratio $\frac{1}{r}$ determines the efficiency of the constant temperature engine, as the Carnot cycle may be named.

It follows, therefore, that for engines employing adiabatic compression and expansion, there are three symmetrical types of thermodynamic cycle which are each cycles of maximum thermal efficiency for the conditions assumed. Although only in one—the Carnot cycle—do the conditions allow the maximum possible heat conversion between the upper and lower temperature limits. They may be called :—

Constant temperature type or Carnot cycle.
Constant pressure type or Brayton and Diesel ; and
Constant volume type or Explosion engines with previous compression.

The same formula applies to all three.

Fig. 6 shows values of r from 0 to 100 plotted against $E = 1 - \left(\frac{1}{r}\right)^{.4}$ the corresponding thermal efficiencies. The curve rises very steeply to $r = 6$ when the thermal efficiency is 0·51 at $r = 12$ E becomes 0·63 and at $r = 18$ E is 0·68. At these intervals of 6 the rises are 0·51, 0·12, and 0·05 from $r = 18$ to $r = 100$ E. only rises to 0·84. The rate of rise falls very rapidly, so that the difference between $r = 50$ and 100 respectively only raises the efficiency value from 0·79 to 0·84.

Obviously compressions or expansions above 20 are not worth consideration by the engine designers ; indeed in constant volume engines the value $r = 7$ is the highest in ordinary use and in constant pressure engines (Diesel) 12 to 14 is not at present exceeded.

If now the diagrams shown in Figs. 2, 3, 4 and 5 be compared, it is at once evident that the Carnot cycle diagram could not possibly be applied to an actual working engine. The engine would necessarily be heavy, because of the high pressure of compression, 500 lb. per square inch absolute, and for this high pressure only 6 lb. per square inch is available to do work. Such an engine would not have power enough to turn itself round.

The diagram, Fig. 4, of the constant volume engine is much more practicable. Here the same maximum pressure is attained, it is true, but the mean available pressure is 105 lb. per square inch, so that the ratio between mean and maximum is relatively favourable. Such an engine as this is quite practicable.

In this particular modification of cycle the ideal efficiency is 0·48. The constant pressure diagram shown at Fig. 5 is still more favourable. Here with the same maximum pressure, 500 lb. per square inch absolute, and the same maximum temperatures, there is obtained 117 lb. per square inch effective mean pressure, and the efficiency is ·56. The indicator diagram shown in Fig. 3 is similar to Fig. 5, but the expansion is carried to atmosphere. This increases the efficiency from ·56 to ·64, but at the expense of a drop in mean effective pressure to less than one-half.

The four diagrams are compared in the table here given :—

Air Standard Diagrams. Figs. 2, 3, 4 and 5 Compared.

Figs.	2	3	4	5
Air standard efficiency	0·64	0·64	0·48	0·56
Mean pressure lbs. per sq. in. ..	6	56	105	117
Max. pressure lbs. per sq. in. ..	500	500	500	500
Ratio $\frac{\text{maximum pressure}}{\text{mean pressure}}$	83	8·7	4·8	4·3

Obviously Fig. 2 (Carnot cycle) with a ratio of maximum to mean pressure of 83 is impossible for any practicable engine. Fig. 3 is better, but even 8·7 is too high when it is seen from Fig. 5 that a ratio of 4·3 only involves a fall of thermal efficiency from 0·64 to 0·56. The remaining Fig. 4 constant volume explosion cycle has a ratio of 4·8, but its thermal efficiency is only 0·48. The best diagram is that of Fig. 5, combining high mean pressure, high thermal efficiency, and the low ratio of 4·3 between maximum and mean pressure. This is the cycle used in Diesel type engines. The maximum pressures are all the same—500 lb. per square inch absolute.

The use of the air standard thus shows the lines upon which to design engines of practicable proportions, and had the working fluid of the internal-combustion engine really consisted of pure air, and had it been possible to avoid all heat losses, then mean pressures, maximum pressures, expansion lines, compression lines and thermal efficiencies could have been calculated for every engine. It has always been known, of course, that in all internal-combustion engines there are considerable heat losses to the enclosing walls of the cylinder and piston, and it has also been known that the mixture of nitrogen, carbon-dioxide, steam and oxygen which constitutes the real working fluid of these engines, has properties which are materially different from those of air. Until a few years ago, however, these properties were only approximately known, and accordingly in the earlier tests for determining the limits of thermal efficiency it was considered best to deal first with the air standard only.

Fig. 4.

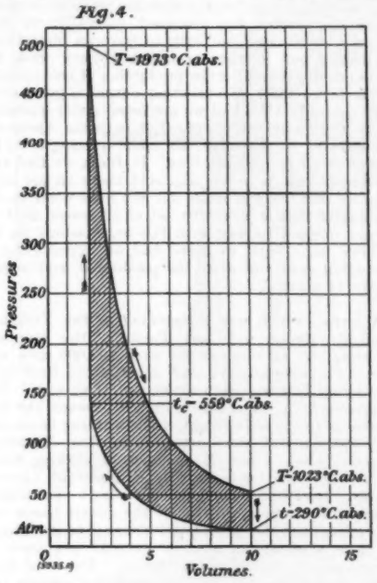


FIG. 4. DIAGRAM OF AIR ENGINE. CONSTANT PRESSURE TYPE.

Fig. 5.

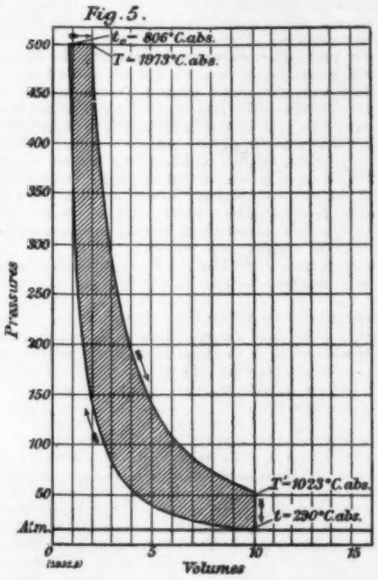


FIG. 5. DIAGRAM OF AIR ENGINE. CONSTANT PRESSURE TYPE. (LIMITED EXPANSION.)

Fig. 6

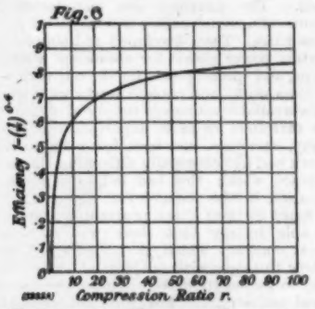


FIG. 6. THEORETICAL THERMAL EFFICIENCIES FOR DIFFERENT COMPRESSION RATIOS IN THE THREE SYMMETRICAL CYCLES.

(To be continued.)

PROPOSED METALLURGICAL EXCHANGE AT ZURICH.—It is proposed to establish a metallurgical exchange at Zurich. The proposal is being put forward by the Société pour Valeurs de Fer et d'Acier, Schaffhouse. It is considered that such an exchange, which would meet regularly every Friday, would give an opportunity to English firms to send a representative to Zurich where he could get into direct touch with buyers in Switzerland in the easiest possible manner. The organisers propose to circularise their intentions by sending the circular to prominent British firms who might be interested.

DETERMINATION OF EXPLOSION TEMPERATURES.—The determination of the temperature attained during an explosive reaction has so far only been possible by indirect methods, depending either upon the measurement of the heat involved and of the specific heats of the products, or upon the measurement of the gas pressure and volume obtained in a bomb. In both cases it is doubtful whether methane is formed at the moment of the explosion or during the subsequent cooling, and further, in how far the formation of methane and hence the gas volume are influenced by the density of the charge. As a consequence the temperature estimates are uncertain by several hundred degrees Centigrade. Direct determinations of the methane percentage at the moment of explosion have been attempted by Koehler and Poppenberg. They found very little methane, but they were not satisfied with their determinations, and in recent years it has been considered advisable to presume the direct formation of methane by explosions in guns. In the *Comptes Rendus* of August 19 last Henri Muraour describes experiments devised to settle the question of the methane formation. He makes use of an "erosion-bomb" of the type used in the Laboratoire Central du Poudre, a bomb from which the gases evolved can escape through a bore of 1 mm. diameter. The steel bomb is connected with another larger bomb of 4 litres capacity, which is previously evacuated. The gases forced through the narrow canal are hence rapidly cooled by expansion in the receiver-bomb, into which, to hasten the cooling, some silver or mercury is introduced. The bore is partly plugged with lead to keep down the gas loss during the period of inflammation. In some cases the canal was pierced through silver (instead of steel). This change made no difference in the results. The figures deduced—the analytical method is not explained—are said to prove that practically the whole—if not the whole—of the methane finally found in the combustion products of explosives (various numbers of BM_3 and of BF powders giving much methane are mentioned) is formed during the cooling period. In contradiction to the previous presumption, it would thus be correct to calculate the CH_4 formed back into $CO + H_2$. It would also follow that, in cases where carbon is not deposited, there has been no volume contraction at the moment of the explosion, such as the formation of methane would imply, and that the density of the charge does not raise the temperature of the explosion.

INDUSTRIAL NOTES.

WE deal in another article in the present issue with the question of the price of coal.

Speaking at the annual meeting of the General Electric Company, Limited, held in London, on the 9th inst., Mr. H. Hirst, chairman and managing director, stated that the company's specialities, which were manufactured regularly during hostilities, did as much to assist in the successful prosecution of the war as guns and shells. He referred to such items as lamp carbons for searchlights, of which the company were the only producers in this country; the Admiralty and War Office required not only the whole carbon output of the works, but requested that this should be doubled. The company also manufactured trench telephone sets, trench cables and magnetos in astounding quantities. They developed and supplied wireless apparatus, power plants for munitions works and for warships, and special plants for the recovery of potash. Their glass works and ebonite works were at one time the only available sources of supply of certain qualities of raw materials for most important war work. The company, therefore, had been fortunate in that their war work had not essentially differed in character from their peace work; this had led to a minimum disorganisation in the change-over.

In regard to their Peace programme, they aimed at being able to say that there was no conceivable electrical contract which they could not undertake and carry through, with products of their own manufacture, so far as these were within the realm of the electrical industry. "The war had created a new strategic position," added Mr. Hirst; "we have to face competition from America, Japan and other countries immensely strengthened through the war. We must also realise that Germany, assisted by the low value of the mark and by American support, may make herself seriously felt again in the markets of the world, and render enormously difficult, if not impossible, the work of reconstruction which now faces this country, as its most gigantic task."

He was glad to say that the extensions which were in hand had thus far enabled them to reinstate their demobilised men without discharging and causing hardship to the other workers, but a great deal of the labour at the moment had to be re-trained, and had to regain the atmosphere of the factory and the office.

He could thoroughly understand the present lull and indecision which pervaded the ranks of the workers after five years of unparalleled mental and physical strain. We were all undergoing this experience in a more or less degree. At the same time, he believed it was beginning to be realised by all classes that the higher standard of living to which the country had attained during the war could only be maintained by increased production. The millions of Treasury notes that were floating about conveyed an impression of wealth. People should realise that these notes, created during the war, were practically nothing else but I.O.U.'s on account of values to be created also. The quicker we created these values and redeemed the I.O.U.'s the sooner we should be normal, and every section of the community, employer and employed alike, would reap the full benefit of their efforts. If we did not create wealth quickly, the value of sterling would drop, our national credit must suffer, and we should be relegated to the rank of a second-class nation. There was no question but that we were "up against it." We must work or starve, but with conscientious endeavour on the part of every worker, combined with quantity production methods, he believed we should be able to satisfy the legitimate demands in respect to both wages and hours. Capital and labour working in the closest association would win through, and together build up this country and Empire into a prosperous Commonwealth, in which every worker would have a full share.

According to the Paris journal *L'Eclair*, many of the United States iron and steel establishments are now working at 65 per cent. or 70 per cent. of their present capacity, which in a large number of instances corresponds to 100 per cent. of the pre-war capacity. It is probable that before the end of the year these same establishments will be working at 90 per cent. of their present capacity.

Trading in iron and steel products with the Far East and South America continues to grow, says *The Iron Trade Review*, Cleveland, Ohio. While there is no purchasing for future delivery, export agents are favourably impressed by the present activity. Notwithstanding the restrictions on European business, Americans still are looking for orders from Europe, and are using their best influence with the political and financial interests to further this object. The inquiries from Italy have been extremely heavy, and in some instances orders have been booked for pig-iron, scrap and other material, only to find that it is impossible to obtain an import permit from the Italian Government.

The leading bankers of New York held a meeting in the middle of June, and an unofficial committee of five is now at work devising some plan whereby European credits may be set up in the United States.

Mr. Reginald Ford came to New York last June as representative of Rumanian interests, declaring he desires to purchase some 50,000,000 dols. worth of steel, provided the credits can be arranged. One of the projects in view is a bridge across the Danube, for which, approximately, 12,000 tons of steel will be needed. If the arrangements cannot be carried out in the United States, an attempt will be made to find accommodation in England, and failing this, the negotiations will be taken to the Continent. The Europeans are in a desperate need, but their financial requirements are of primary importance.

Our American contemporary adds that the Shipping Board, according to rumour, will sell and allow to be built in American yards, about 1,000,000 tons of ships for the French. The immediate French requirements appear to be agricultural implements. It is estimated that France needs 51,000 side hill ploughs, 33,000 plain ploughs, 56,000 cultivators, 88,000 harrows, 16,000 beet extractors, 36,000 seed drills, 18,000 horse rakes, 53,000 root cutters, 30,000 mowing machines, 115,000 farm wagons, 50,000 rollers, 48,000 hoes, 13,000 fertiliser spreaders, 21,000 winnowing machines, and 32,000 reapers and binders.

South America and the Far East continue to afford the best markets for the United States.

Referring to the Act for reducing the miners' working hours, *L'Echo de la Bourse*, Brussels, says this means the consecration of the minimum effort, without any heed to corresponding effects upon reconstruction. We may be convinced that Germany will not be guilty of such mistakes.

Speaking of the signing of the Peace Treaty, the *Revue Générale de l'Electricité* says that certain international questions dealing with labour could not be decided upon by the political plenipotentiaries alone, and specialists had to be called in. This is, no doubt, the reason why Mr. Jouhaux, secretary of the "Confédération Générale du Travail," was invited to form part of one of the commissions of the Congress for France. It was quite in order to take into account the ideas and the wishes of the working classes. But it seems to have been forgotten that these latter are not the only ones interested in such questions. Three elements, or divisions, always intervene in any industrial undertaking, and no one element can effect anything without the co-operation of the two others. In order that labour may find employment, there are required a technical direction and also capital, and it is astounding that no delegate of the technical element, in other words, no engineer, and no delegate of the employers, should have been invited also to the Congress. It is to be hoped that, in future, further questions of importance will not be dealt with without inviting representatives of the three.

After a stoppage of three weeks, work was resumed last Monday in the Lancashire cotton industry, following upon meetings of representatives of the Federation of Master Cotton Spinners' Association and other organisations. Work was resumed on the following bases:—(1) The 48-hour working week; (2) an advance of 30 per cent. on the standard piece price list rates of wages; (3) an equivalent alteration in rates of pay in the case of those workpeople whose wages are not covered by a standard piece price list; (4) the 48-hour working week to remain in operation without change for a period of 18 months from the date of this coming into operation, and after the expiration of that period one month's notice to be given by either side of any desired alteration; (5) the altered rates of pay to come into operation when work is resumed, and to remain, in operation without change until April 30, 1920, either side desiring an alteration in such rates of pay to give one month's notice, but such one month's notice shall not be given at an earlier date than March 31, 1920.

Mr. Smillie delivered an address to the annual conference of the Miners' Federation, at Keswick, last Tuesday, when the following resolution was adopted unanimously:—

"That this conference, having noticed the political and industrial pressure now being brought to bear on the Government with a view to getting it to ignore the recommendations of the Coal Commission as expressed in the report of the majority of the Commissioners on the second stage of the Commission's work, informs the Government that, whilst the miners are not fully satisfied with the report of Mr. Justice Sankey in all its details, they are prepared to give the Government their fullest support in carrying the recommendations of the Majority Report of the Commission into immediate effect."

Difficulties have arisen between the engineering trade unions and the engineering employers concerning the 47-hour week. The 47-hour week was agreed upon by the operatives, but they have since put forward a demand for a 44-hour week, which the trade unions appear to support. The report for the present month of the United Society of Boiler Makers and Iron and Steel Shipbuilders refers to meetings with the employers on this same question. In the course of one of these meetings, Sir Allan M. Smith, chairman of the Management Committee of the Engineering Employers' Federation, said:—

"As was arranged with you on the previous occasions when the matter was discussed generally, we were to be allowed, and you were to have an opportunity of finding out whether or not a 47-hour week was economically sound for the production of this country. What do we find? We find that output is going down very seriously. We find we are being under-quoted in every market in the world. Not only the Americans but actually the Germans, are under-quoting us to the extent of 25 and 30 per cent. In India we find that machinery can be made and sold there 25 per cent. cheaper than we can make it. We have come to the conclusion that it would be out of all reason that we should proceed further with the negotiations on the 47-hour basis until we have had an opportunity of discussing with you what the position is with regard to the 44 hours."

A strike, which was threatening in the Yorkshire coalfields, broke out last Tuesday, the stoppage throwing out of employment over 150,000 men and boys. For several days past negotiations have been proceeding between the owners and their men. The disagreement is due to a difference between the two parties as to the adjustment of the working hours and the settlement of piece rates. The West Yorkshire owners offered to put the question of working hours before the Coal Controller, the Minister of Labour, or Mr. Justice Sankey; at Tuesday's conference, however, the representatives of the miners threw out that offer, since the owners declined to give the miners on piece work an advance of over 12 per cent. in compensation for the shorter hours. The Coal Controller, it is reported, at first told the owners the advance should not exceed 10 per cent.; he then made this 12 per cent. The men, on the other hand, contend that the West Yorkshire owners have gone back on their word to grant an advance of 14·3 per cent. to the men on piece work, an advance, they allege, the South Yorkshire owners have agreed to allow.

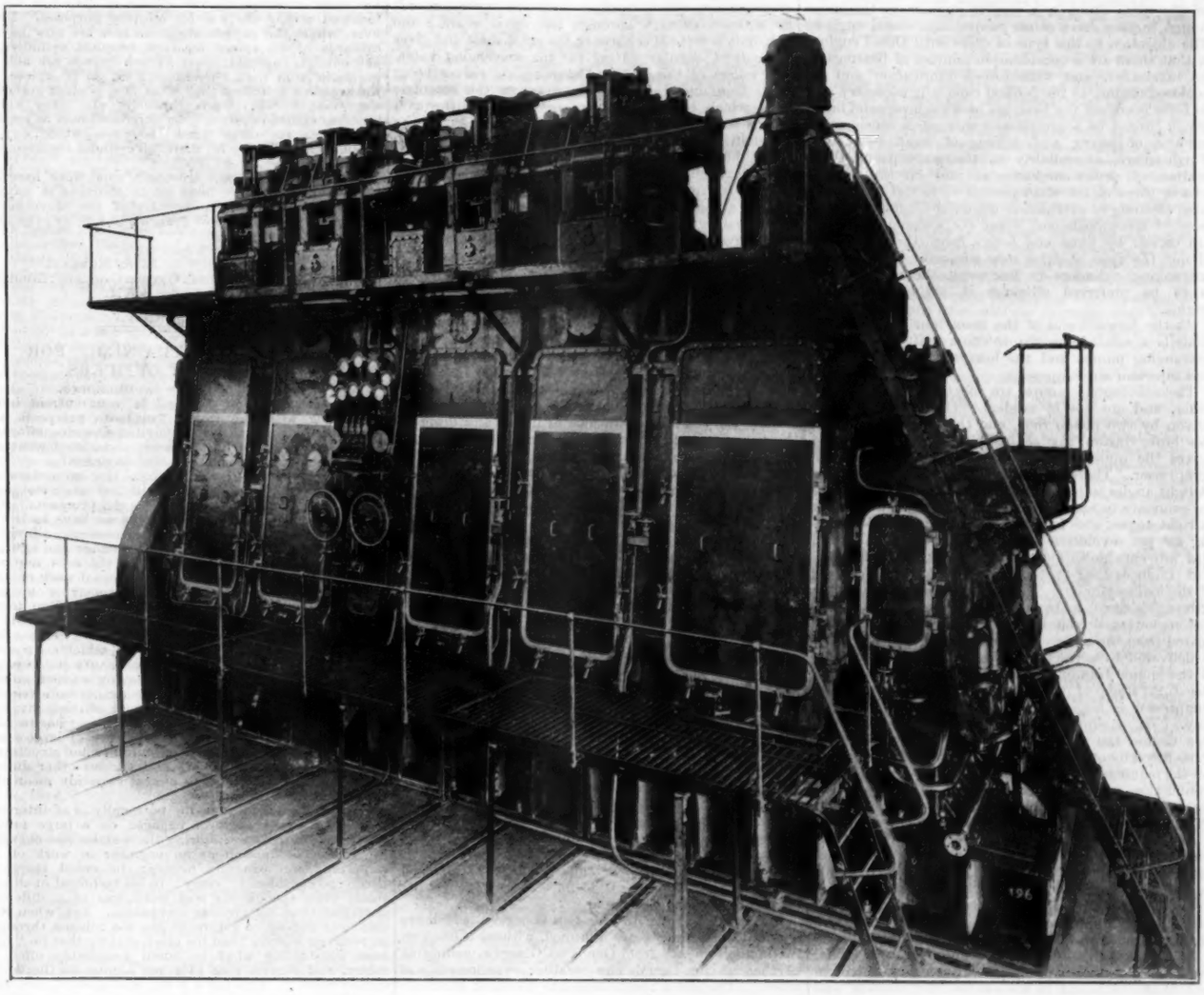
THE ANSALDO-SAN GIORGIO MARINE OIL ENGINE.

The stimulus of war conditions towards increased shipbuilding has been felt in every Allied and neutral country, and only now when news is permitted to be fully disseminated, can a full appreciation be obtained of the progress made. Modern Italy during the last generation has been rapidly developing its engineering resources and particularly during the war the industry of shipbuilding. Due to the high cost of coal and the severe difficulties of transport, the oil engine has been rapidly and very highly developed. An excellent example of the progress made and the present position of Italy, amongst the engineering nations, is the twin screw motor vessel "Ansaldo-San Giorgio I," built by the Ansaldo-San Giorgio Company, of Spezia. The owners are the Societa Nazionale di Navigazione, of Genoa. This vessel is of 8,100 tons deadweight and 5,663 tons gross, having a speed of 11 knots. She has completed her maiden voyage from Genoa via Carthagena to Glasgow, carrying 7,600 tons of iron ore. The main propelling twin screw Diesel oil machinery, which presents the greatest interest, is situated aft and the cargo holds are free of pillars. The ship is divided by eight water-tight transverse bulkheads.

The main engines were designed and built by Messrs. Ansaldo-San Giorgio, of Turin—one time the F.I.A.T. San Giorgio—and follow generally in design the same policy as earlier products from these works. The two-cycle principle with valve-controlled port scavenging is retained, and the appearance of this engine can be seen from the engraving on the opposite page. Each engine has four working cylinders, of 630 m.m. diameter (24¾ in.) by 900 m.m. (35 7/16 in.) stroke, and running at 100 r.p.m. develops 1,100 brake horse-power. This speed of revolution is that for which the propeller is designed. At this speed and horse-power the mean effective pressure on a brake horse-power basis is 64 lb. per square inch. This, then, is the maximum figure for mean effective pressure at which the engines are called upon to work at sea. The piston speed at 100 r.p.m.

FOUR-CYLINDER TWO-CYCLE MARINE OIL ENGINE.

CONSTRUCTED BY MESSRS. ANSALDO-SAN GIORGIO, TURIN, ITALY.



is the very moderate one of 590 ft. per minute. The speed of revolution of 100 r.p.m. and the speed of ship of 11 knots will give a relatively high propeller efficiency.

If conditions were suitable for a higher speed of revolution, say, for instance, such as to give a piston speed of 800 ft. per minute or approximately 135 r.p.m., the brake horse-power with the same mean effective pressure of 64 lb. per square inch would be of the order of 1,500 brake horse-power. One of these engines as a matter of fact, during comprehensive trials in the shops at Turin, developed 1,800 brake horse-power. The unit cylinder of this engine is one of the largest and highest powered in marine practice. In connection with the main features of construction, reference should be made to the description of the F.I.A.T. two-cycle six-cylinder engines of the Brazilian Submarine Depot Ship "Ceara" which appeared in ENGINEERING of November 1, 1918, page 482. The engines now under description have the same dimensions of cylinders, but have four instead of six cylinders and embody a considerable number of improvements in design resulting from experience gained during the intervening period. Both engines are totally enclosed for forced lubrication. The main cast iron framing follows generally the same design. One important difference, however, falls to be recorded. With the "Ceara" the through bolts for relieving the main framing of tension loads extended only from the top of the entablature to the bottom of the bedplate. The cylinders of the "Ceara" engines had not separate liners, and the tension stresses consequent upon the cylinder pressure passed through the main cylinders which were bolted to the entablature.

With the engines of the "Ansaldo San Giorgio I" a novel type of structure is adopted. Each main cylinder is suspended by light studs from a heavily ribbed cast steel frame of square form in plan, which is supported from the entablature by four turned steel columns. Other distinct columns extend from the top of the entablature to the bottom of the bedplate. This type of construction is quite clearly seen in the engraving, and leaves the cylinders quite free to expand downwards, sliding through the entablature, which bearing prevents lateral movement. The cylinder construction also is novel. Each cylinder has a simple water-cooled head. The cylinder exhaust and scavenging belt comprise one casting, and the cylinder water-cooling space is formed by a corrugated sheet steel sleeve, as can be seen in the illustration. The corrugations allow for expansion.

The side thrust of each connecting rod is taken by four water-cooled guides, the same type of construction of four guides per cylinder as in the Ceara's engines being embodied. When comparing this type of construction with similar designs as adopted in some large steam engines, it must be borne in mind that, with Diesel engines, forced lubrication is general, that the thrust each revolution, contrary to steam engine practice, passes from the front guide to the back, and that the engine framing is not liable to distortion, due to conducted heat as with steam engines. For these reasons the guides and slippers can, with Diesel engines, be much more closely set up in erection without fear of working conditions giving rise to reduced clearances and overheating—the possibility of which is further reduced by the ample supply of lubricant under pressure which it is possible to arrange. This arrangement of guides makes more easy of accomplishment the removal of main pistons for inspection from below which, with this type of framing, is the method adopted, and is in general the procedure to be desired. It further secures exceedingly simple access for inspection through the large sheet metal doors to all the main, crank-pin and cross-head bearings.

The pistons are water-cooled by fresh water, and the water is led in and out of the pistons by dipping pipes. The arrangement of guards for preventing the leakage of water into the crank-chamber is particularly neat. After the maiden voyage, no sign of leakage having taken place was evident. The relatively low piston speed of 590 ft. per minute will undoubtedly make for easy running conditions of the glands for this water service. Circular inspection doors through which, during running, the working of all these important parts can be examined will be seen in the illustration; there are two doors per crank. Over each crank-pit is located an electric light illuminating the working parts. The design of the dogs, six per door, securing these large hinged doors against oil leakage, but permitting of access within one minute, gives evidence of careful attention in design to small but important details. In connection with the question of accessibility, it might be stated that a man can easily stand up inside the crank-chamber whilst the engine is running. The piston

cooling water for each cylinder is led outside the crank-case into a very neat fitting where the quantity flowing can be seen and the temperature recorded.

With the engines of the Ceara the inverted scavenging pumps of the usual double-acting type, were driven by levers and links from the main crossheads of three of the main units in a similar manner to the usual design for the drive of air pumps with steam engines. The objection to this type of drive with Diesel engines is that there are a considerable number of bearings to be lubricated, and with forced lubrication and an enclosed engine, as the general rule, it is necessary also to force lubricate the bearings of these levers and links, which cannot be accomplished without a considerable amount of piping and drilling of small holes, &c. Furthermore, accessibility to the main pistons is a matter of prime importance, and—in the case of two or three of the main pistons—removal for inspection, cleaning or overhaul is rendered considerably less easy of accomplishment when the scavenging pumps are driven by links and levers from the crosshead. Hence the type of drive now adopted, of having the scavenging cylinders in line with the main cranks, is to be preferred although it involves a longer engine.

At the forward end of the main four throw crank-shaft is a small three throw crank-shaft driving two scavenging pumps and the low-pressure stage of the fuel injection air compressor.

The scavenging pumps are located one above the other, and are not in tandem. The lower piston is driven by two piston rods, and through the centre of the lower piston the centre piston rod passes and drives the upper piston and the L.P. piston of the compressor. The two cranks for the lower piston are at right angles to the centre crank. This design makes for economy in length of engine and the cranks, being at right angles, give four periods of delivery of scavenging air per revolution—two from each cylinder—and this prevents pulsations in the scavenging air delivery and conduces thus to maximum efficiency of scavenge of the main cylinder. The suction and delivery of the scavenging air to and from these pumps are controlled by piston valves driven by a small horizontal lay-shaft geared from the main crankshaft. The scavenging air is delivered to a reservoir formed in the entablature of the engine framing. Similarly the suction valve of the L.P. stage of the three-stage fuel injection air compressor is a piston valve controlled in the same way. In passing, it may be remarked that with this engine the scavenging pumps are smaller than those fitted by other makers of two-cycle Diesel engines, yet the requisite efficiency of scavenging to give complete combustion and a low consumption of fuel per unit power developed, with a high output of power per unit of main cylinder capacity, is obtained.

At the forward end of this pump group is a single crank driving the H.P. and I.P. stages of the compressor, which are in tandem. With the Ceara's engines two compressors per engine with the balanced lever type of drive, were provided. Increased experience, and the confidence thereby obtained, permits of a single compressor of sufficient power being fitted.

Forward of this again is the pump group. These double-acting plunger pumps are driven from the main crankshaft. Inboard in tandem are the sanitary and bilge pumps and outboard, also in tandem, are the sea water pump for circulating the cooling water through the jackets, and the fresh water pump for supplying the cooling medium to the main pistons. This pump draws from a separate tank of 3 tons capacity. Below these four pumps is a gear wheel type of pump for forced lubrication oil. Around these pumps are grouped the coolers for the air between the L.P. and I.P. stages and the lubricating oil, and two-way filters for the lubricating oil.

One interesting detail is, that in order to prevent the fresh water from arriving at the main pistons at too low a temperature, it passes first through the air cooler and, in extracting heat from the air, is there somewhat raised in temperature.

Being of the two-cycle port scavenging type, the valve gear is very simple. Spiral gearing from the crankshaft drives a vertical shaft located between cylinders numbers 2 and 3. Spiral gearing again gives motion to the camshaft completely enclosed, force-lubricated and running in bearings a foot or so below the top of the cylinders. For each cylinder there are five cams; one scavenging valve cam, actuating the piston valve which controls the entry of scavenging air to the ports, two cams for the fuel injection valve (one for ahead and one for astern) and similarly two for the starting air valve. The fuel injection and starting air valves in the cylinder heads are actuated by short push rods and levers eccentrically mounted on the continuous fulcrum shafts as shown. From the camshaft the two lubricators for the cylinders are also driven by eccentrics as shown between cylinders numbers 1 and 2 and 3 and 4 as well as gear for operating the indicators.

To set the camshaft for ahead or astern running, the vertical shaft is either telescoped or elongated, according to whether the engine is being reversed from ahead to astern or astern to ahead, through the agency of compressed air, To prevent this action from being too rapid there is fitted an oil dash pot arrangement, which ensures that the operation will be without shock. Through the spiral gearing the camshaft is rotated relative to the crankshaft and gives the correct angular setting for the scavenging valve. The rollers of the fuel and starting air valves being lifted from off their cams by rotating the eccentric upon which the valve levers are mounted, the cam groups for these valves are slid longitudinally on the camshaft by a shaft internal to the camshaft and so bring the required cams into operation, after which the rollers are lowered on to the cams, and the engine is ready for running in the desired direction. Reversal can be accomplished in less than 10 seconds, and is facilitated by relief valves in the cylinder heads which, when reversing, are actuated by compressed air and relieve any compression remaining in the main cylinders. During normal running, these valves, one per cylinder, function as ordinary safety valves, and their springs are set to blow off at the desired pressure.

The controls of the engine are conveniently grouped towards the centre on the starting platform as shown in the illustration. The two valve chests at the forward end are the master valves for the supply of fuel injection, air and starting air. The foremost hand wheel is the flywheel of the compressed air servomotor controlling the starting operations of lifting and lowering the rollers on the cams and controlling at the same time the starting air control valve, fuel injection air controls situated on the cylinder tops, as well as the cylinder head relief valves, all operated through pilot valves. This device controls also the fuel injection pumps in keeping with the manœuvring of the engine. The servomotor is controlled by the small handle shown above the flywheel. There are four fuel injection pumps grouped at the centre controlled by hand, by Aspinall governor to prevent racing and also through mechanism by the servomotor as already mentioned.

The after servomotor serves for the reversal of the engine, and sets the camshaft, &c. Should the servomotors fail, then the operations can be carried out by hand, by means of the handwheels shown, although the time taken is naturally much longer. A small engine which can be worked by either steam or compressed air serves as a turning engine and is geared to the flywheel which weighs some 12 tons. The small wheel seen above the forward servomotor controls the opening of the throttle valve in the air compressor suction, so that the air compressor can readily be set from the starting platform to give the quantity of air required for the speed of revolution at which the engine is running.

The fuel consumption of these engines at all normal powers is approximately 0·43 lb. of heavy fuel oil per brake horse-power per hour.

The engines of the Ansaldo-San Giorgio I, which are self-contained ran, we are informed, without a hitch on the maiden voyage from Genoa to Glasgow, calling at Carthagena for cargo. The weather experienced was severe. The speed maintained was good and the revolutions averaged some 90 r.p.m.

So far as can be judged from an external inspection, the workmanship is of the highest order. The finish of the working parts gives evidence of the pride of the constructors in their product. The engine room is commodious and sets off these two large engines to considerable advantage. In the wings are fuel oil tanks and at the forward end of the engine room are the steam driven auxiliaries of the usual reciprocating type, namely a steam driven ballast pump, a fuel oil pump and a standby water circulating pump. The air bottles for compressed air storage of 2000 litres, or 70 cubic feet capacity, are located on the forward bulkhead. At the after end of the engine room are the lubricating oil tanks, and above the thrusts are two steam driven generator sets each of 50 amperes 112 volts output, and each sufficient for the lighting of the ship.

In a compartment on deck are two "Blake" type donkey boilers, fitted for oil fuel burning and provided with the necessary pumps, filters, heaters, &c. In the same compartment the auxiliary condenser with its circulating pump and a standby steam driven air compressor for charging the compressed air bottles are installed. The silencers for the exhausts from the main engines are also situated in this compartment. Thence the exhaust gases pass to the funnel. With the exception of the two donkey boilers of the "Blake" type and the oil fuel plant, the whole machinery, main and auxiliary, was manufactured in Italy, and is testimony to the progress being made in Italy in marine construction.

The ship and machinery are classed with the British Corporation of Glasgow.

GAS CYLINDERS.

TO THE EDITOR OF ENGINEERING.

SIR,—Your correspondent, "Hydrocyl," and others who are unable to obtain adequate supplies of oxygen at the present time through cylinder shortage, will be interested to know that a similar difficulty in France has been overcome by the release of cylinders manufactured during the war for military purposes. Moreover, whilst the oxygen suppliers here are now paying upwards of 4*l.* apiece for new seamless cylinders of 100 cub. ft. capacity, their French friends are able to purchase from their Government for 85 fr. apiece, all the seamless cylinders they want of a popular standard size—viz., 7 cub. meters capacity. In other words, seamless cylinders can only be purchased here at present in driblets for three times the price which oxygen suppliers have to pay for their full cylinder requirements in France.

It is quite true that transport conditions here are very bad, but there need be no shortage in oxygen supplies throughout the country if the Government will follow the example of France and sell, or even hire, on reasonable terms.

Yours truly,
K. S. MURRAY,
(The British Oxygen Company, Limited).
Elverton-street, Westminster, S.W.1.
July 14, 1919.

ENGINEERING TRAINING FOR DEMOBILISED OFFICERS.

TO THE EDITOR OF ENGINEERING.

SIR,—The letter of "B.Sc." in your current issue, concluding with the words "ultimate prospects and scope for their abilities which civil engineering affords," moves one to ask if he has really considered what are the "ultimate prospects" in civil engineering.

If "B.Sc." will look through the advertisement columns of your own paper, he will find many instances which should enlighten him as to the prospects. For instance, during the last two weeks we have had, *e.g.*, a large northern town advertising vacancies, and inviting applications for positions of chief assistant and another assistant to the borough engineer; the men required are to be thoroughly qualified in the usual work of such a department, surveying, building construction, preparation of specification and schedules and so forth, preferably connected with the Institution of Civil Engineers. For these posts the salaries offered are 250*l.* per annum, and 150*l.* per annum, which are respectively a little more and a little less than a journeyman artisan will earn, such a man having earned money during his apprenticeship, and having no more responsibility than that of proper treatment of the individual piece of work on hand, whereas the engineer has to take the responsibility of proper expenditure of large sums of money, the efficient design of buildings and structures, supervision of contract work and various other duties, failure in any of which will almost certainly mean the collapse of his "prospects."

Another case known to me personally is of interest: that of a young engineer engaged on a large public works before the war; during the war he was engaged in civilian occupation as an engineer in work of an important and exacting nature; he could therefore hardly be considered "rusty" in his technical qualifications, even though his war work was of a different character from his pre-war occupation. Yet, when this man was hoping to return to see the scheme through, he received a letter from his chief, stating that he "had been considering what he could reasonably offer as salary, and suggest that 130*l.* per annum be the figure agreed upon." This for a B.Sc., also aged 27, and one considered—at any rate, to judge by the work at various times entrusted to him—to be thoroughly capable and well up in his work. It is hardly necessary to say that the figure was *not* agreed upon, a figure about that of a street sweeper or apprentice boy in a workshop on piece work.

Another northern city, a very large one, advertises for a temporary assistant in its waterworks department, and offers—only temporarily, with obviously no security of tenure—the sum of 200*l.* per annum—a trifle more than a tram driver or new policeman gets.

The list of such cases is repeated week by week.

In making comparisons with the wages earned by the "working-classes"—which usually means the man who takes his coat off to a job, as distinguished from the man who does not—one does not begrudge them good wages and conditions in the least, but it is obviously ridiculous for young men to spend time and money in expensive scientific education, and later to have to read continuously to keep abreast with ever-changing modern practice in his profession, when they can, in the majority, rarely hope to earn as much as the foremen and navvies under them, much less to an easier time in their old age. It is easy, of course, to repeat pious phrases about "always room at the top," but not everyone can be at the top—not even every very capable and talented man, and it is my opinion that even at the top there is nothing great in the way of monetary reward.

"B.Sc." may, of course, be one of those who have no objection to going abroad to his work, and there are, of course, good positions in the foreign field, though in most cases the increased pay is largely offset by increased costs and decreased health, and he can, in such case, hardly look forward to marriage or any normal home life.

To my mind, the essential trouble with civil engineering is that money expended in civil engineering undertakings is usually considered as buried and lost, and rarely is an investment, and in order to reduce this hidden treasure,

the pay of the technical staff is cut down, that being the only vulnerable point; contractors are not in business as philanthropists, workmen have their fixed rates; the engineer is the only man who has no defence or organisation against the profiteer.

It is also rather surprising that the leaders in the profession have in many cases such a low opinion of their own profession that they think fit to offer men with wide and varied qualifications salaries that any mechanic would refuse.

If, therefore, "B.Sc." has no influence, which one gathers he has not, otherwise he would not have written as he did, and if he is not reconciled to a life abroad (he need not look to America, for a little reading of, for example, *Engineering News and Record*, will soon convince him that the civil engineer is little better off there than here, in spite of the much less developed state of large areas requiring his services) he would be well advised to "cut his losses, including his B.Sc. (which will anywhere be of use to him, for it will have taught him how to think and reason), and seek one of the posts in trade or commerce to which he refers as offering higher remuneration at present. He may rest assured that unless he becomes an artisan, his financial reward will very closely vary inversely as the useful value added to the article in which he deals.

Much the same applies to the large numbers of young fellows now proposing to take advantage of the State scheme of University training for ex-officers and men of the Forces. In a few years the market will be flooded —probably in a time of great trade depression, to judge by the present trend of affairs—with young men with little experience but great hopes, and a degree in engineering of one branch or another, all looking for good jobs with salaries adequate to reward them for the lost years of war. Such instances as I have quoted of the pay offered to experienced men, should be a warning as to what the inexperienced may expect; let them not be led away by misleading books on "What Shall my Bright Boy Become?" and so on.

No one who has been fortunate enough to have such a thing will, as a "higher" education, but its financial value in the engineering profession (in any of its branches) is very seriously open to doubt. I was speaking a short time ago to the ex-head of the electrical engineering department in one of our British Universities, and I asked him point blank if he thought that, considered as a paying proposition, the time spent in a University course was worth while; the subsequent salaries of the students who passed out of the University with which he was connected could not justify him in saying that such time was profitably spent. The technically-trained man certainly, in the main, will receive more eventually than the purely practical man, but he rarely gets anything like the pay that a man of equal responsibilities in a trading concern or commercial department will get.

All those, therefore, who propose to sell their brains in the open market, would be well advised to look before they leap.

Yours truly,
"B.Sc., No. 3."

July 10, 1919.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The increase in the price of fuel hangs like a cloud over every branch of trade, and makers generally are agreed that its effect on industry will be little short of disastrous. Already many of the most important branches are feeling the effect of high costs of raw material, and in some instances find that American products can undercut them in the home market. The additional 6*s.* per ton on coal will, it is feared, shut them completely out of the neutral markets of the world. Business since the Armistice has been patchy. Inquiries have poured in from all parts of the world, but these have not to a substantial extent been followed by orders. Indeed, practically, the only expansion has been in those branches which were already overstocked with work, and which have found the greatest difficulty in increasing their output. The crucible and open hearth steel sections have been flat ever since the cessation of hostilities. Generally, it is estimated that fully 40 per cent. of the open hearth steel capacity is idle, and certainly in this district that is fully borne out, for nearly half the open hearth and the majority of the electric furnaces are standing. Short time is being worked in all the crucible branches, and the immediate outlook is far from promising. Business in railway steel is below the normal level, but makers of shipbuilding material and all classes of goods used in automobile construction, on the other hand, are working under the utmost pressure. Generally, the introduction of the eight-hours' day has resulted in a lessened output *per capita*, with substantial increases in production costs. The iron market is strong at the advanced prices. East Coast mixed hematites are quoted at 10*l.* 6*s.* 9*d.* delivered, and West Coast at 10*l.* 10*s.* The advance in billets has checked sales. South Yorkshire bar iron is now quoted at 21*l.* 10*s.* for crown bars delivered, an increase of 20*s.* Overseas trade, as might be anticipated with the freedom of the seas again assured, is expanding. Belgium has been buying freely, while Greece and Russia are showing increased activity. India is a strong market for railway material.

South Yorkshire Coal Trade.—Supplies of coal to Sheffield alone, says the secretary of the Coal Exchange, have, since the beginning of June, been 1,000 tons per week below the normal. The decreased output of the pits is having a disastrous effect on business. For house coal the pressure on the collieries has been greater than ever. Merchants have been inundated with stacking orders; it has been found impossible to obtain extra supplies, and they have notified their customers that all deliveries after the 16th inst., even where orders have been booked for weeks, will have to be at the advanced rate. The advance practically stopped business on the Coal Exchange, and, generally speaking, the utmost alarm is experienced in the market concerning the outlook. Best steam hards and other reserves at the collieries are going away day by day with consumers pressing for supplies for stocking purposes. Cobbles, nuts and slacks are all strongly held, contractors taking practically the whole of the output with the exception of inferior qualities of slacks. These, for the time being, are on the weak side, and stocks are accumulating at the pits. All classes of coke are in a strong position with maximum prices the general rule. The new rates are as follows:—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best Silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 28*s.* 6*d.* to 29*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.* 6*d.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is practically suspended pending a more definite knowledge of the coal situation. Quotations are nominally unchanged, but, of course, it is impossible to place orders in face of the fact that a 6*s.* rise in coal would mean something like 15*s.* added to the cost of producing pig-iron. Ironmasters are most reluctant again to advance the already very high prices, but with a substantial advance in fuel, they will be compelled to do so. The fact that business is at present held up is not of serious consequence, for makers are so well sold that they have very little iron to offer, most of them having disposed of their output to the end of next month. At the same time, it is highly desirable that this state of uncertainty should be dissipated as soon as possible. The prevailing opinion is that any further substantial advance in pig-iron would admit of makers in America and Luxemburg sending their iron into this country, for already those competitors threaten to do so, and they are snatching customers abroad who used to take all their supplies from this district. Nominally, quotations are unchanged at: No. 3 g.m.b. and No. 4 foundry, 160*s.*; No. 1, 164*s.*; and No. 4 forge, 158*s.* for home purposes, and 5*s.* above these rates for export.

Hematite Iron.—East Coast hematite was difficult to purchase for prompt delivery before the question of coal prices created the existing state of uncertainty which has accentuated the prevailing scarcity. Business is impossible, and quotations are nominally 200*s.* for home use, and 205*s.* for export of Nos. 1, 2 and 3; and 202*s.* 6*d.* for home consumption, and 207*s.* 6*d.* for export of No. 1.

Foreign Ore.—There is a fair amount of business passing in foreign ore. The action of the Shipping Controller of diverting homeward-bound light vessels to Spanish ports, has resulted in quite a glut of ore boats, with the result that freights have further fallen, and imports have been on a satisfactory scale. The freights Bilbao-Middlesbrough is now round about 27*s.*, which makes best rubio quotation in the neighbourhood of 56*s.*, ex-ship Tees.

Manufactured Iron and Steel.—Finished iron and steel makers keep busy, and there are still substantial home and foreign inquiries in the market, but there is practically no new business passing. With a further rise in quotations, which would be rendered necessary by increased cost of output, as the result of an advance in fuel, grave apprehension is felt that America and other competitors might not only capture some of our trade in foreign markets, but might be able to send their products into this country in no inconsiderable quantities. Quotations are quite nominal at the following for home consumption:—Common iron bars, 20*l.* 10*s.*; marked bars, 23*l.*; strip iron, 21*l.* 15*s.*; ship rivets, 27*l.* 10*s.*; steel ship, bridge, and tank plates, 17*s.* 15*l.*; steel angles, 17*l.* 5*s.*; steel joists, 17*l.*; heavy steel rails, 16*l.*; steel hoops, 23*l.* 5*s.*; galvanised sheets, 27*l.* 10*s.*; and black sheets, 22*l.* Export quotations are matter of negotiations.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—Labour troubles continue to affect the coal export trade, and the announcement that inland prices are to be increased 6*s.* per ton and the export minimum prices raised 6*s.* per ton, has kept new business in check, sellers being reluctant to make fresh transactions pending developments. On Monday, the whole of the tippers at the Bute Docks, Cardiff, came out on strike, because of a number of their members having been given notice that their services would no longer be required. Consequently, loading operations are entirely suspended, and up till to-day no settlement had been reached. The trouble which is not unlikely to spread to other ports will, if prolonged, seriously affect collieries. Already they are feeling the pinch by a shortage of transport facilities and every day increases the difficulties. Some collieries have already been rendered idle by a lack of wagons. The seven-hours' day becomes operative in the coalfield to-day, and this will further handicap the export trade, for even with the eight-hours' day sufficient coal was not raised to meet the requirements of foreign consumers. The only bright spot in the situation is that the miners' leaders now evidently realise the vital necessity of increasing outputs, and serious steps are now likely to be taken with this object in view. It is officially announced that no further licences will be granted for the shipment of coals to France for the quarter ending September, as already the licenses granted exceed allocations. This will hit some exporters hard, for there are a number of firms who have orders but have not yet obtained their licences. Meanwhile business is quiet and prices irregular. Buyers able to take spot delivery for export are able to secure supplies at prices materially below those indicated for shipment even a couple of days off, but there are very few able to take advantage of this. For loading at the end of this week or early next week, from 15*s.* to 20*s.* over Schedule A prices for Allied countries are secured.

Newport.—There is a good inquiry for Monmouthshire coals, and prices rule firm, and for shipment next week Eastern Valley, Black Vein and Western Valley large coals range from 55*s.* to 60*s.*, while good smalls are worth from 40*s.* to 45*s.*

NOTICE OF MEETING.

THE MIDLAND INSTITUTE OF MINING, CIVIL, AND MECHANICAL ENGINEERS.—Thursday, July 24, at The University, St. George's Square, Sheffield, at 3.30 p.m. Annual Meeting: The following papers on "Some Suggestions for the Standardising of Guarantees for Coal Washeries," and on "The Effects of Coal Mining on the Over-lying Rocks and on the Surface," by W. D. Lloyd, will be open for discussion.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—On the eve of the annual midsummer stoppage, there has been the usual activity at the various steel works in Scotland, and a large output has been general during the past week. The conditions in the industry have not appreciably changed, and there still continues to be a very pressing home demand, particularly for ship and boiler plates. The announcement by the Government that an advance of 6*s.* per ton was to be made in the price of coal came as rather a staggering blow to the trade, as none quite expected so heavy a rise. The present high costs are already all against any expansion in the export side of the business, and if prices must be further advanced there seems little chance of re-capturing our foreign markets for some considerable time to come. In the meantime, as the proposed advance has been delayed until Monday, by which time the works here will be on holiday, the Scotch steel makers will have time to consider the position carefully before work is resumed. If the price of fuel is to be raised then an appreciable advance in the price of steel will be necessary from August 1, as present quotations only hold good until the end of this month. Sectional material shows no change, but a healthy demand exists for steel sheets and a large turnover is general, chiefly in the thicker gauges.

Malleable Iron Trade.—During the past week there has been quite a respectable output from the malleable iron works in the West of Scotland, but smaller, nevertheless, than should have been. The demand has been large and buyers are all eager for more than it is possible to give them under existing conditions, with the result that expansion in the export trade is well-nigh impossible at present. Inquiries continue on a large scale. Prices are meantime without change and very firm, owing to the heavy costs and dear labour. If coal is raised there must, in consequence, be an advance in present quotations.

Scotch Pig-Iron Trade.—There has been no falling-off in the demand for Scotch pig-iron, and every available ton is quickly taken up by consumers whose requirements it would seem impossible to satisfy. The prospective rise in coal will be a most serious thing for the trade, if it is finally agreed upon, because of the necessary advance which will have to be made in the price of pig-iron. The Scottish ironmasters considered the position at a meeting in Glasgow on Monday, when it was decided, after some discussion, to adjourn until after the Fair Holidays, when the matter of future prices would be gone into and fixed up. In the meantime, endeavours are being made to obtain a reduction in the cost of the freight on ore from Spain, and there is some prospect of this being successful. Both foundry iron and hematite are in great demand, and the steelmakers are consuming as much of the latter as it is possible to get. Prices are very firm.

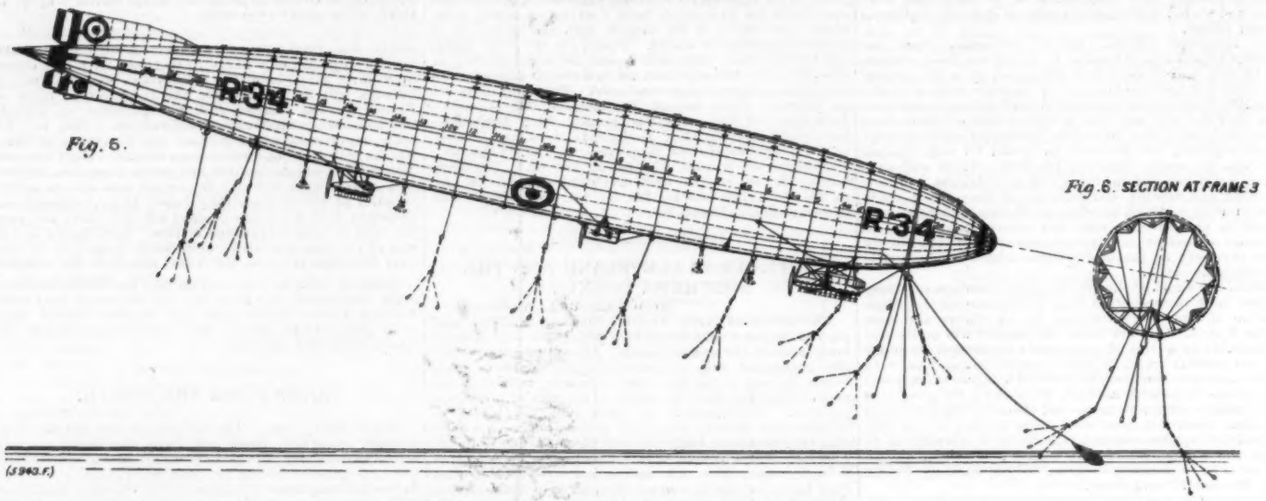
Scotch Coal Trade.—A very heavy demand has been experienced by coal masters during the past week for supplies for the various industries, and some difficulty has been experienced in meeting the orders. The railway requirements are also on a large scale, but deliveries for gas works are not quite so pressing. Dross is a glut on the market. The export trade is better and shows signs of some improvement. Prices are firm and sellers are not committing themselves ahead on account of the present position.

DRYING PULVERISED COAL.—In MR. L. C. Harvey's valuable paper on the "Use of Pulverised Coal," of which we gave the first portion in our issue of the 11th inst., reference is made on page 67 to the Ruggles-Coles Dryer, which has been largely used in America. In view of the interest which is at present being taken in the use of pulverised coal, it is desirable to state that the Ruggles-Coles Dryer is being manufactured in this country at their works at Stoke-on-Trent, by Electro-Metals, Limited, who are the sole licensees and makers of this type of patented dryer in Europe.

H.M. NAVAL AIRSHIP "R. 34."

CONSTRUCTED BY MESSRS. WILLIAM BEARDMORE AND CO., LIMITED, ENGINEERS, DALMUIR.

(*For Description, see Page* 87.)



FIGS. 5 AND 6. HANDLING AND MOORING ROPES.

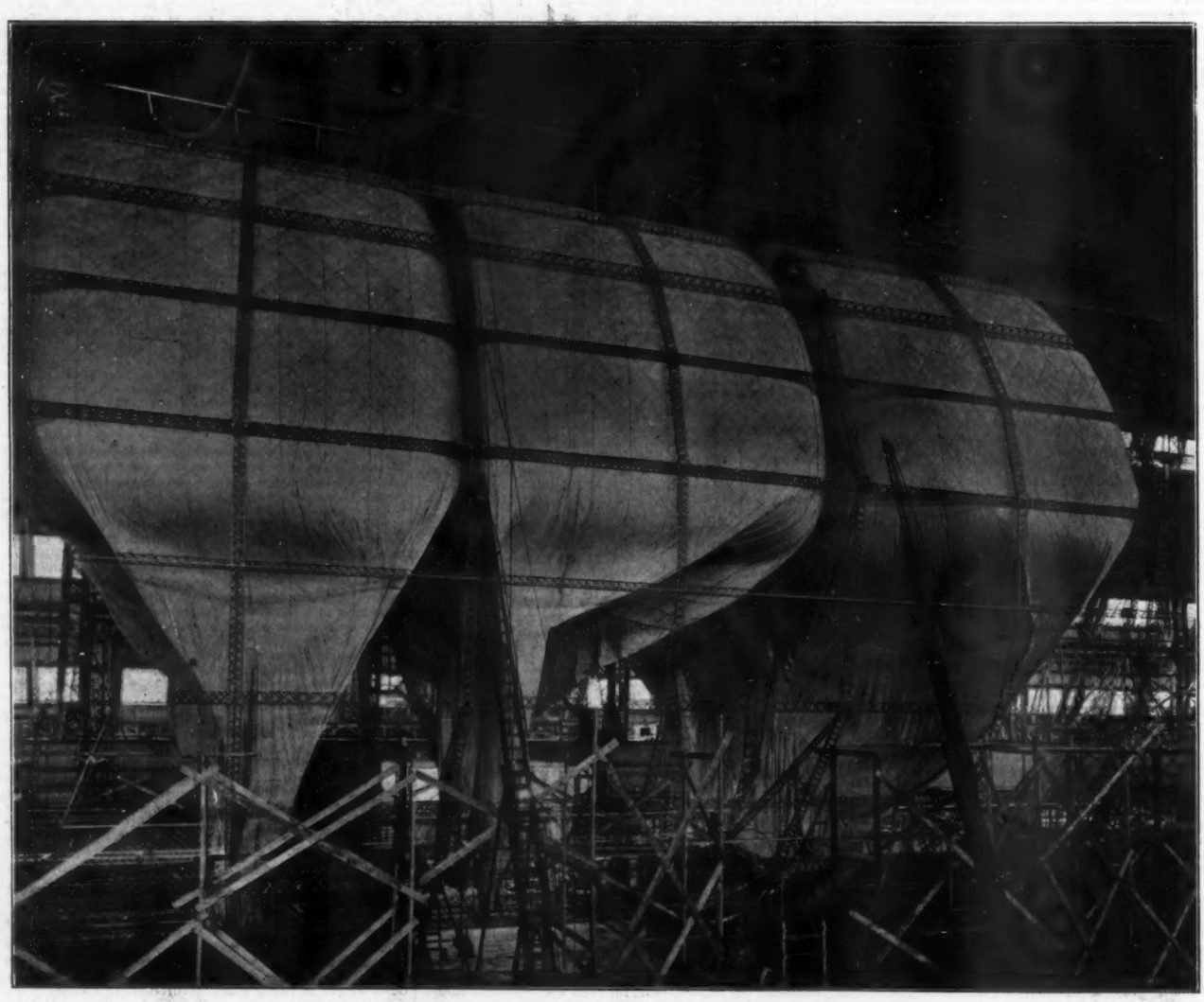


FIG. 7. THREE GAS BAGS PARTIALLY INFLATED.

HIS MAJESTY'S N L A

CONSTRUCTED BY MESSRS. WILLIAM BEAR AND CO

(For Descr Page 87.)

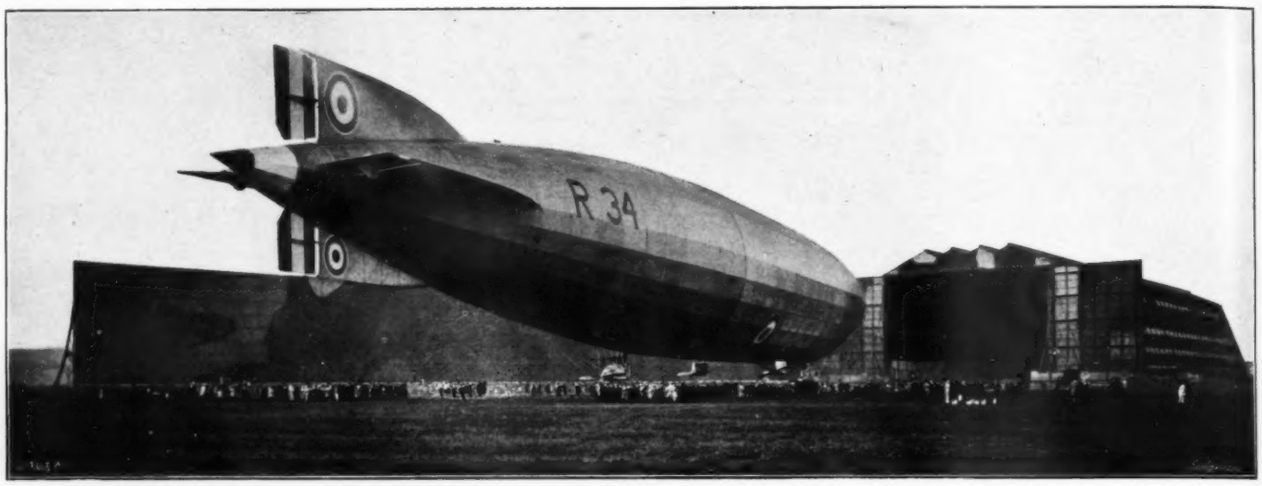


FIG. 1. AIRSHIP LEAVING SHED AT INCHINNAN.

FIG. 3. INTERNAL VIEW OF HULL FRAMING ON SEGMENTAL SADDLES DURING CONSTRUCTION.

NAL AIRSHIP "R. 34."

BEARDMORE AND CO., LIMITED, ENGINEERS, DALMUIR.

(See Page 87.)

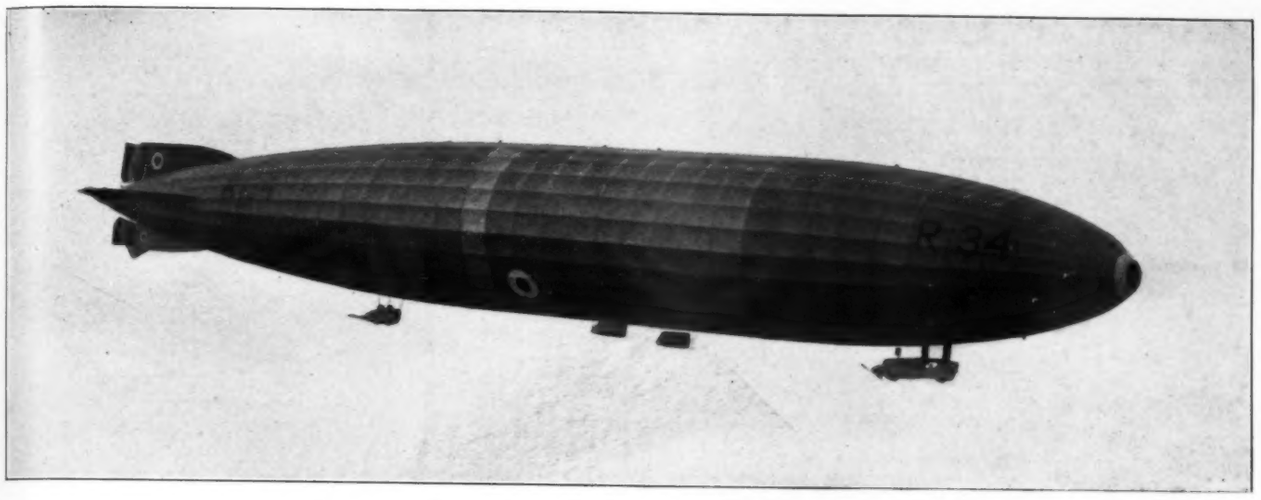


FIG. 2. AIRSHIP READY TO COMMENCE FLIGHT.

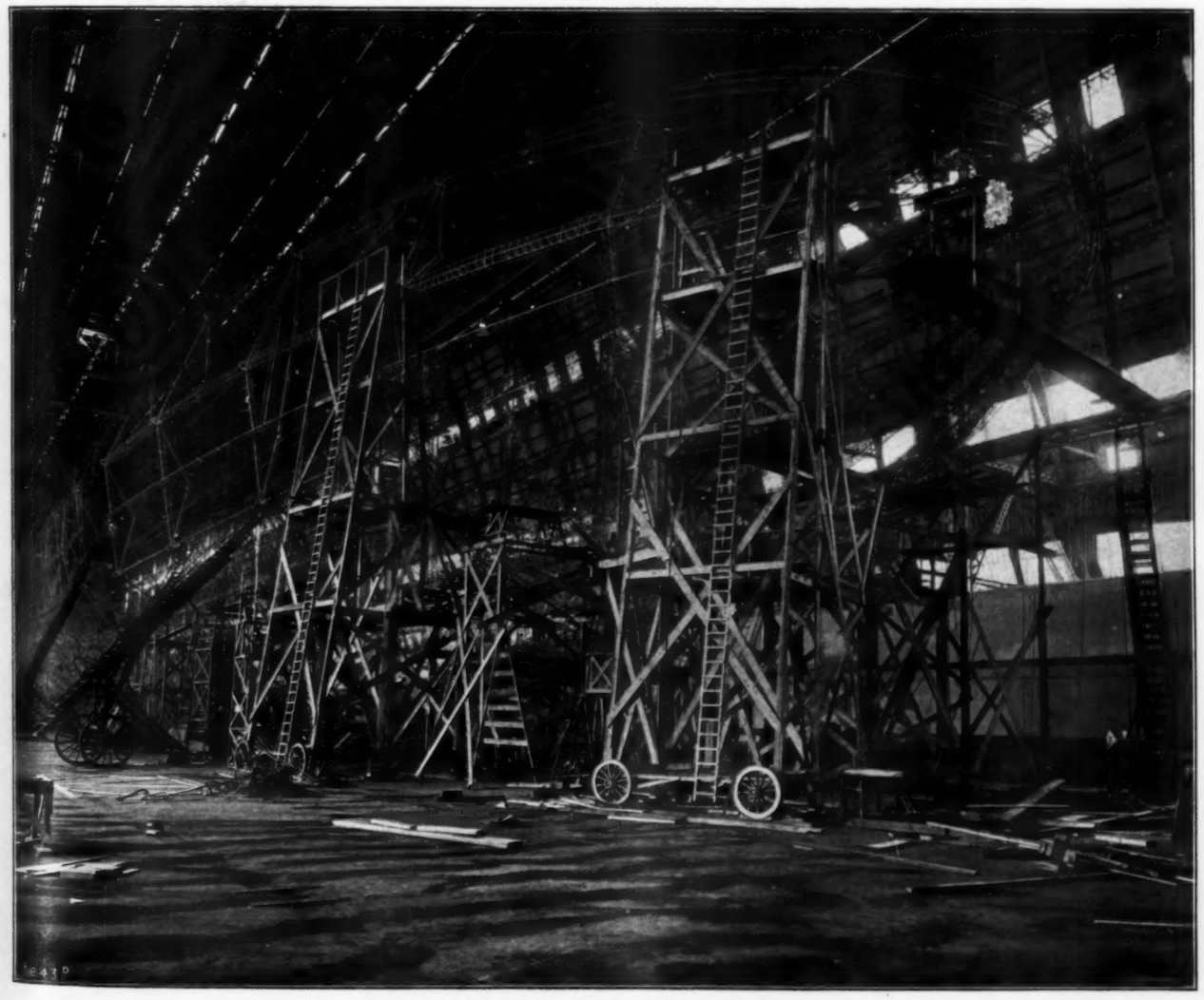


FIG. 4. EXTERNAL VIEW OF FORWARD PORTION OF HULL FRAMING DURING CONSTRUCTION.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication, and certainly not later than Monday morning.

SUBSCRIPTIONS, HOME AND FOREIGN.

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Thick ,, ,,	£2 9 6
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Thin paper copies	£2 9 6
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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3063 and 8596 GERRARD.

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With a Two-Page Plate of HIS MAJESTY'S NAVAL AIRSHIP "R. 34."

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 83.

ENGINEERING.

FRIDAY, JULY 18, 1919.

THE PRICE OF COAL.

THE action of the Government in deciding last week that the selling-price of coal should be raised by 6*s.* a ton, was entirely sound. Such an increase would be a very serious matter for practically all industry, but a still more serious matter for industry would be for the country to continue longer its rake's progress of living on borrowed money and subsidising everything. In the debate on the coal situation in the House of Commons, last Monday, Mr. Hartshorn said "It was not only in the mining industry that the situation was serious. They had a subsidised railway, subsidised agriculture, subsidised building, subsidised Post Office, and now they were faced with subsidised mines. They only needed to place the textile and metal trades in the same position and they would be bankrupt." We are glad this came from a Labour member. We are not going to make any attack on labour, but think it will be admitted that the labouring classes, as a whole, probably realise the economic situation in which the country is now placed somewhat less fully than other classes. The first and hardest step in our climb to sounder conditions is to make our people understand that the only way to lower prices and increase employment is for everyone to do an honest day's work for a day's wage, no matter who they are and what they may be doing.

This is a matter not only for miners and bricklayers; but concerning ourselves with the coal industry alone, it would be interesting to know if the miners are the only people who are not doing all they might. In the House of Commons debate, to which we have already referred, Mr. Brace quoted evidence of miners being unable to work and of pits being laid idle on account of various shortages. He stated that £43,249 was paid in out-of-work benefit in the South Wales area last year—benefit that is for genuine lack of work and having no connection with sickness or strikes. The question of shortages was dealt with very fully by Sir Eric Geddes in the debate. His arguments were legitimate and his facts, no doubt, correct, but in the emergency in which we are now concerned it is to be hoped that it is not only the miners who will be urged to do their best towards output. Let the appeal be wider and let it cover all concerned with coal getting, above all let it cover all Government employees who can help or hinder. Concerning the latter class, Mr. Brace mentioned a possible and even probable loss of output in connection with the fixing of the new piece-work rates necessary in consequence of the reduced hours. The miners' demand may be excessive, but be it what it may, the matter has to be settled sooner or later, and yet according to Mr. Brace the Coal Controller's Department has simply allowed matters to drift.

The appeal which has been addressed to the miners' patriotism in this emergency we support and extend to the patriotism of every one concerned with coal getting. None the less we are not satisfied with patriotism as a working basis for the success of coal-mining, or any other industry. In the emergency in which the country finds itself, we favour any appeal which will help, but we must build on something more than that. Some way or another our collieries must settle down to a day by day and every day common round of work which will produce all the coal we require for internal use and export at an economical price. By all means let us have a special effort for an emergency, but let us also re-build the industry so that the everyday work of the everyday man fits into the common economic scheme and pays its way. The present position is that the miner is receiving enormously more money and, turning out less coal than before the war. The miner is charged with slackness, but it is admitted that he is hampered by lack of wagons, &c. The division of the fall in output quantitatively between these two causes has, as far as we know, not been attempted.

In the proposal to put the selling price of coal up to something nearer its cost the Government showed prevision and an attempt be made to reduce the coal situation to a business footing. In their failure to inquire into the true facts of the present situation they have shown no prevision. In 1912 the tons of coal produced per annum per person employed in collieries in the United Kingdom was 245. In the same year the figure for the United States was 660, and for Australia 542. At the present time the cost of coal for export is 39*s.* a ton, and according to Sir Eric Geddes, the average quality is not very good. At the same time the cost of American coal f.o.b. Atlantic ports is 20*s.* a ton. What is the meaning of these relative figures? In a general way everyone knows the explanation. The American miner does not work for lower wages than our miner, but he works either harder or more effectively, and is more helped by machinery. Also, the coal is more easily worked. The information we have not got is the relative incidence of these various factors and this in our opinion, is where the Government has shown lack of foresight. If the Coal Controllers and Chief Inspectors and the rest of them will collect and publish detailed information of these points they will do something on which a future policy may be built up.

The ultimate salvation of the situation must lie either in a reduction of miners' wages or improved output per man. The former no one wishes even to discuss, and the latter if we are to attain, we must tackle in a businesslike way and not merely by charging the miners with failing to work properly. Before the war less than 7 per cent. of our coal was machine cut. Does the Government which controls the coal industry know how much more coal a miner produces with a machine than with a pick? Does the Government know—does anyone know—how much the greater output of the American miner is due to installation of more effective transmission appliances? Sooner or later the coal industry must settle down to a proper basis. That settling down would be enormously helped if the colliery owners, be they private individuals or Government departments, had full and complete information, statistical and technical, showing the effect of various types and classes of machinery installation on colliery output. It is quite likely that the physical conditions of our collieries are such that we can never approach the output per man achieved in the United States, but that is no reason for not doing the best we can do. Information such as we are asking for would enormously facilitate negotiations with the Miners' Federation and would quite possibly permanently scotch the opposition to the introduction of machinery which certainly exists at the present time.

The bringing of the mines to a proper paying everyday basis is what must be worked for, but as we have said, if improvement can be made at once by appeals to patriotism we are very ready to support them. None the less we must not assume that we can live on this sort of thing for ever. The Government's proposal for a 6*s.* increase is postponed to see the effect of the miners "putting their backs into it"—Mr. Bonar Law's phrase. We hope for the best, but what we must insist is that we cannot live permanently on special efforts and emotional appeals. We are rather tired of "dramatic situations" and "pledges" in connection with the coal industry. Let the real facts of the coal output question be investigated and published so that we may know where we stand. Facts will tell in the end whether we investigate them or not. *Magna est veritas, et praevalebit.* If conditions are such in Great Britain that by no good management and installation of labour-saving methods can we bring

our coal down to a price competition with other countries then the present miner's wage cannot ultimately stand. We do not believe that this is so, but for the sake both of the miners and the public it is essential that the facts should be investigated.

We are not quite clear if an enquiry is to be undertaken conjointly by the Government and the Miners Federation to see if the increase of 6*s.* a ton is really necessary or can be avoided. The miners' leaders certainly suggested this, but we are not sure if the Government agreed to meet them in the matter. In any case such an enquiry is far from what we have in mind when we ask for investigation into the possibilities of machinery. We want an enquiry by experts, manifestly not in public, and we want their report to consist in the main of technical facts and statistics. We want no more public enquiries and appeals to the "great heart of the people." Clever management of the Coal Commission by the Miners Federation and the consequent effect on "the great heart of the people" has landed us in a situation which is nothing less than desperate. We do not suggest that a more judicial Commission sitting in private might not have made the same recommendations on hours and wages that the Sankey Commission did, but if they had they would have done so with a fuller knowledge of the effect of their recommendations and with some elementary attempt to suggest in what way the more serious of those effects might be meliorated.

Coal is only a special case, but perhaps the most important, of the difficulties amid which our principal industries are now struggling. For many years past the status of the working-classes in this country has been improving, but the rate of change has been so enormously increased by the artificial conditions of the war that the economic structure has not yet had time to adjust itself. With patience and hard work we may get back to a position of stability again. It is easier to preach patience than for a manufacture to practice it when he is faced with coal at £2 a ton or so, and yet there is no doubt but that even with wages where they now are the country might be more prosperous than ever before. The manufacturer, however, must now face the situation as it is, and primarily in his own hands it lies to ascertain that he is not at present wasting coal. The inflated price may in some instances prove not an unmixed evil. There is no doubt at all but that in the past an enormous amount of coal has been wasted in this country. It has been cheap enough not to trouble about the matter. It is doubtful if such a state of affairs will ever return. The second way of meeting the situation is to educate the miners to the advantage of improved output not only to the country, but to themselves. In this direction matters, we think, are not unpromising. Most of the labour leaders now admit the importance of increasing individual production and some of this admission must soak downwards to the actual worker.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

THE King struck the right note, when he telegraphed to the North-East Coast Institution of Engineers and Shipbuilders at their "Victory" meeting to the effect that he earnestly trusted "that the influence of the Institution will be energetically exercised in the work of reconstruction and of revival of trade so indispensable to the future prosperity and general well-being of the Empire." This is a task which is fully recognised, not only by the members of this Institution, but by all similar organisations, and proof was afforded throughout the proceedings of the "Victory" meeting, which was held at Newcastle-on-Tyne, from Tuesday to Friday of last week. The title of this particular session was justified first by the inclusion in the general proceedings of the presentation of the honorary freedom of the city to Marshall Foch, O.M., Admiral of the Fleet Sir David Beatty, and Field-Marshall Sir Douglas Haig, and also by the general character of the papers read, which dealt largely with work done for the war and the significance of its experimental character with reference to future developments from the scientific standpoint. The banquet, which was held on Tuesday, following the presentation of the freedom, was the largest attended, and all the speeches, including those from the Home Secretary, from Sir Douglas Haig, Sir David Beatty, and Lord Weir, were concentrated on the importance of increased production, a necessity which we have repeatedly enforced.

The technical proceedings commenced on Wednesday, after the Commemoration Service, in the Cathedral Church of St. Nicholas, for members of the Institution who had fallen in the war. A happy inaugural incident was the presentation of the Honorary Fellowship of the Institution to distinguished engineers. This rank was only recently instituted, and there was peculiar appropriateness in the first honorary fellowship being conferred on the Hon. Lady Parsons, who has done so much for the recognition of women in the engineering factories, and particularly in establishing the necessity for such women becoming highly skilled in a profession which they have invaded with much advantage to the State. The other honorary fellowships conferred were those upon Marshall Foch, Sir David Beatty, Sir Douglas Haig, Lord Weir and Sir Joseph Maclay. The first paper read was by Lady Parsons, on "Women's Work in Engineering and Shipbuilding during the War," and this we published on page 62 of last week's issue. Lord Weir proposed a vote of thanks to Lady Parsons, and stated that his experience was that for the highest classes of work it was possible to train women in a much shorter time than it was possible to train men. He thought he could prophesy with complete safety that the present position, under which trade unions granted full equality in everything to women with one exception—that was, opportunity—would be given up. The second paper was by Mr. A. H. J. Cochrane, Secretary to Sir W. G. Armstrong, Whitworth and Co., Limited, and gave a short record of the work of the principal industries on the North-East Coast during the war. This, naturally, was largely of a statistical and detailed character of the work done. It may be noted that the total of ships of all kinds from the Tyne, Wear and Tees during the war was 1,130 vessels of all sizes and descriptions, with a tonnage of 3,324,912. Taking the duration of the war as 221 weeks, that meant an average of five ships per week. The engine output was correspondingly large.

At the meeting on Thursday, great interest was taken in the first paper read, which was by Lord Weir, and dealt in a comprehensive manner with developments in aircraft design and application during the war. We began the publication *in extenso* of this valuable contribution to the literature of this subject on page 59 of our issue of last week, and we continue it on page 93 of this week's number; the concluding part, dealing with the engines of aircraft, will be published in a later issue. In the discussion which followed the reading of the paper reference was made to the relative value of the airship and the aeroplane. Sir Charles Parsons, who opened the discussion, said that, in 1912, he expressed the opinion that the airship would have the biggest future, and he still thought that was true. The airship would be relied upon for long-distance work, as, with all the skill and experience of those concerned, there would still be breakdowns in aeroplanes and the risk was too great. General Groves of the Royal Air Force, agreed with this view. He was inclined to think that for non-stop runs, say, over 2,000 miles, the airship in the future would probably have it all its own way. A large aeroplane or seaplane would serve for a shorter distance. Professor J. C. McLennan, F.R.S., gave a lecture on science, and its application to marine problems, dealing largely with the problems which had been set down for solution by the Scientific Board at the Admiralty, to which he was Scientific Adviser. We hope to publish this lecture in an early issue, so that there is no need, in this short notice, to enter into the Professor's discussion of all the many inventions in the implements of war used by our ships, especially during the later years of the naval campaign. At the afternoon meeting on Thursday, Sir Dugald Clerk, F.R.S., read the first paper, on "The Limits of Thermal Efficiency in Diesel and other Internal-Combustion Engines." We begin the publication of this paper on page 77. Lieut.-Commander Norman Wilkinson read a paper on the Dazzling of Ships, which we hope to reproduce in an early issue. In the evening of Thursday there was a reception by the Lord Mayor. This, it is interesting to note, was the only social function of the meeting.

The single paper read at the meeting on Friday, was by Mr. M. C. James and Mr. Launcelot E. Smith, and dealt with ship repairing during the war. The meeting was one of the most successful held by the Institution, and much credit for this is due to the care devoted to all details of organisation by the secretary, Mr. E. W. Fraser Smith, and to the efforts of the sub-committee, of which the president of the Institution, Mr. E. L. Orde, was chairman.

THE MINISTRY OF WAYS AND COMMUNICATIONS.

THE Ministry of Ways and Communications Bill has now passed through the House of Commons, and the attitude of the House of Lords will be watched with interest. There was again much criticism of the provisions of the Bill in the House of Commons during the report stage, and once more important amendments were made. Indeed, it has become quite evident that the all-embracing nature of the Bill as originally drafted was entirely out of harmony with the opinions of the majority of the public and of members of the House of Commons.

The Second Reading of the Bill—dealt with in our issue of March 21 last—was noteworthy for the capitulation of the Government upon the clause which proposed to give the Minister power to nationalise railways by an Order in Council. It was, however, also noteworthy for the attitude adopted by Sir Eric Geddes in his desire to be given unfettered control over the various means of transport covered by the Bill. Stage by stage important modifying revisions have been made, and the final stage in the House of Commons witnessed the Minister-Designate in a much more conciliatory frame of mind. As the *Times* remarked, "Sir Eric Geddes was both meek and plausible," although "the earlier history of the Bill makes his present protestations entirely unconvincing." Moreover, he unavailingly sought to explain the inaccuracies in his statement upon the first reading of the Bill. The most important of these was the definite assertion that the railways were being worked at an annual loss of something like 100,000,000*l.* As we stated at the time, he made no attempt to prove the accuracy of this estimate, and, therefore, we urged that the Government should submit a detailed statement of railway receipts and expenditure for each of the years 1915, 1916, 1917 and 1918, setting out the receipts for passenger traffic, freight traffic, and the estimated value of traffic carried without charge on behalf of the Government, and, on the other hand, the expenditure in the different departments of the railway administration in respect of materials and wages. We had the strongest reason for believing that if such a return were produced it would show that Sir Eric Geddes would find it impossible to substantiate his statement that there was a loss of 100,000,000*l.* a year in working the railways. The subsequent publication of the statement for which we asked proved that the view we had taken was a just one, and that the figures given by Sir Eric Geddes were inaccurate.

The outstanding amendments made on the report stage in the House of Commons were in relation to harbours, docks and roads. The opposition to the granting of powers to the Minister to acquire dock undertakings has been ably voiced by Mr. Joynson-Hicks and others, and as the result of a deputation received by the Leader of the House before the report stage, an amendment was agreed which took away the right of the Minister to take possession of docks and harbours, and exercising the powers under clause 3 of the Bill, while allowing him to retain the power to require improvements to be undertaken for the purposes of transport, subject to the right of the dock authorities to appeal to an arbitrator if they think it would be injurious to their undertaking or the trade of the port. This

amendment, which now becomes clause 4 of the Bill, is as follows:—

"Nothing in section three of this Act shall apply to any harbour, dock or pier undertaking established by Act of Parliament, including the Manchester Ship Canal, but not including any harbour, dock or pier forming part of a railway undertaking, or to the owners of any such undertaking without the consent of such owners, but if at any time during the two years after the passing of this Act the Minister shall consider that it is desirable in the national interest that the transport facilities and accommodation at the harbour, or at any dock or pier of the owners, should be improved or extended, or that the method of working should be altered, the Minister may, by order, for the purposes aforesaid, require the owners to execute or do, within a reasonable time, such improvement or extension or alteration in the method of working as the order may prescribe, and may for that purpose confer on the owners any such powers of acquiring land or easements or constructing works as are mentioned in paragraph (*d*) of sub-section (1) of that section.

"Provided that if the owners of such undertaking consider that any such requirements are likely to be seriously injurious to the undertaking, or to the trade of the port, they may, within thirty days of receiving notice of such requirements from the Minister, appeal, in the case of an undertaking situate in England or Wales, to the Lord Chief Justice of England, or, in the case of an undertaking situate in Scotland, to the Lord President of the Court of Session, or, in the case of an undertaking situate in Ireland, to the Lord Chief Justice of Ireland, and if it appears to such Lord Chief Justice or Lord President that a *prima facie* case is made out that the requirements of the Minister would be so injurious as aforesaid he shall forthwith appoint an arbitrator to hold an immediate inquiry, and if the arbitrator reports that the carrying out of the requirements of the Minister will be so injurious as aforesaid, the Minister shall revoke his requirements, without prejudice to the power of the Minister to issue a new order."

In our opinion, the power to be conferred upon the Minister of Ways and Communications, as now expressed in the clause quoted, is amply sufficient, while at the same time the very proper objection of the dock authorities, particularly of such undertakings as the Port of London Authority and the Manchester Ship Canal, to the Bill as originally drafted is largely met.

Another amendment deals with roads, and here again the desire has been to restrict the autocratic powers of the Minister. Following the precedent set up in regard to the revision of railway rates and fares, it has been decided to establish an Advisory Committee, and a new clause (No. 20) in the Bill provides that for the purpose of giving advice and assistance to the Minister with respect to and for safeguarding any interests affected by the exercise of the powers and the performance of his duties under the Act in relation to roads and bridges and vehicles and traffic thereon, a Roads Committee shall be appointed. The Committee will consist of not less than ten members, of whom five will be representative of highway authorities, appointed after consultation with such authorities, and five will be representative of the users of road traffic, appointed after consultation with the interests concerned, together with a chairman and secretary. The latter will be appointed by the Minister. The Committee may make regulations as to their procedure and method of voting, and may at their discretion consider and report to the Minister upon any matters affecting the construction, improvement or maintenance of roads or bridges or the regulation of traffic thereon.

Other minor amendments might be referred to. For example, the reduction in the number of Parliamentary Secretaries from two to one, as in the case of other amendments, is an indication that the country has reached a stage when it is desirous of ridding itself of bureaucratic Government rather than adding to it. The Government have been at pains to disclaim all intention of nationalising the railways under the provisions of the Bill, and for our part we hope that at the expiration of the two years during which the railways will be controlled by the Ministry of Ways and Communications they will be returned to private ownership and commercial operation. All that has happened during the five years of Government control of the railways is that expenses have risen in a most definite manner, due to Government concessions, while, on the other hand, no attempt has been made to adjust charges to the increased cost of operation. The result is that coastwise shipping is strangled and railway companies find themselves faced with a demand to carry coal and other commodities between points hitherto served, and properly served, by water. What is required is a revival of true commercial principles in the working of the railways, and we have little hope that this will come about so long as the railways are controlled. It would most certainly not be restored under any scheme of nationalisation.

H.M. AIRSHIP R.34 AND THE TRANS-ATLANTIC VOYAGES.

THE successful round voyage of the naval airship R.34, completed on the 12th inst., is a further proof of the part played by Britain in the development of the airship as recorded in our articles on pages 757 and 797 of the preceding volume. It is also appropriate that we should supplement these articles and the particulars given by illustrations and descriptions of R.34, which was built by Messrs. William Beardmore and Co., Ltd., at their Inchinnan airship works, which are under the direction of the management of the firm's naval construction works at Dalmuir.

In quite the early stages of the war, Messrs. Beardmore, under the Admiralty, were engaged in supplying many types of aeroplanes and seaplanes for use in the Royal Naval Air Service. It is, therefore, not surprising that when the Admiralty decided, late in 1915, to embark upon a more extensive programme of airship construction, Messrs. Beardmore were among the few firms invited to assist in the work. For this purpose the firm acquired a tract of land of over 360 acres at Inchinnan, on the Clyde opposite Dalmuir, and a large shed for the construction and erection of airships was commenced there in January, 1916. It is to the credit of another local firm, viz., Messrs. Sir William Arrol and Co., Limited, that the construction of the shed had advanced sufficiently by the following July to enable the erection of the first airship to be commenced at that time, the principal parts having been prepared, in the meantime, at Dalmuir. Since the original shed was finished, shops for the complete construction of all parts of the airships, as well as of their gasbags, have been built on the site, the total area of buildings now being 8½ acres. A model village has also been erected close by, for the accommodation of the workers.

The first airships completed at Inchinnan were the R.24 and R.27, but, as we have already illustrated and described one of this class, viz., the R.23, in the articles above referred to, we will proceed at once to describe the R.34. This vessel, which, except for its sister ship the R.33, is, we believe, the largest yet in existence, has a length of 645 ft. over all, and a maximum diameter of 78 ft. 9 in. Its gas capacity is approximately 2,000,000 cub. ft., giving a gross lift of 60 tons under standard conditions. The disposable lift, that is the lift available for fuel, oil, passengers, cargo, &c., is just under 30 tons, so that the ratio disposable lift to gross lift is nearly 0.5, which is an exceptionally high figure for a rigid airship. Figs. 1 and 2 on Plate III, give an idea of the shape and general appearance of the airship. Of these illustrations, Fig. 1 shows the airship leaving the shed at Inchinnan preparatory to a flight, and also shows the elevators and rudders with the horizontal and vertical fins used in conjunction with them. The wind screens, used for protecting the ship while entering or leaving the shed, will also be noticed in this illustration. Fig. 2 shows the airship off the ground, and just getting under way. As will be seen, the hull is of fine stream line form, which should give the ship a very low head resistance. The hull is made up of main transverse frames spaced 10 metres (32 ft. 10 in.) apart, and built in the form of a polygon with 13 sides. At each angle of the polygon the frames are joined in a fore and aft direction by longitudinal girders, and the framework is completed by the introduction of intermediate frames in every space, both transversely and longitudinally. The exterior of the finished framework thus formed, is a polygon having 26 sides, and it is over this that the fabric outer cover is stretched. Our illustrations, Figs. 3 and 4, on Plate III, give some idea of the arrangement of the framing, and in Fig. 3 the actual construction of the girders, which are made of duralumin, can be distinguished. This illustration, which is reproduced from a photograph taken at Inchinnan in June of last year, shows the hull framework resting on segmental cradles, and supported on the latter by trucks with flanged wheels attached to each angle of the framework. This arrangement enables the whole frame to be rotated about its longitudinal axis, and thus greatly facilitates the work of erection. As, however, we explained this system rather fully in the account of the construction of H.M. Airship R.80, at Messrs. Vickers Works, Barrow, given on page 797 of our last volume, we propose to make only a very brief reference to it here. Fig. 4 is an external view of the framework taken about a month later than Fig. 3, and looking on to the starboard side of the bow.

Our illustration, Fig. 6, on page 84, which will again be referred to later, shows the arrangement of the main frames, internal keel girder and transverse bracing. After completing the framework and tightening up the bracing wires, the ship has to be raised from the cradles for attaching the cars or gondolas. This is accomplished by putting the gasbags in position, and partially inflating them with gas. This stage of the work is shown in Fig. 7, on page 84, where three gasbags will be seen in place. These gasbags, of which there are 18 altogether, are composed of high-quality single-ply cotton fabric, lined with rubber on the inner surface. On this surface gold-beaters' skins are stretched and secured with rubber solution, and the whole is then varnished over. By this means a higher degree of impermeability is obtained, with a much lower weight, than was possible with the methods used in the earlier stages of airship construction. Each gasbag is fitted with a relief valve set to blow off automatically when a given pressure is exceeded, and about half the total number are provided with manœuvring valves which enable gas to be released, in any desired quantity, from any of the bags so fitted. The gasbags, as shown in Fig. 7, are not attached to the main structure of the ship in any way, but exert their lifting force by pressing on the whole upper part of the structure. Some pressure must, of course, be exerted on the bracing separating each pair of bags when the axis of the airship is inclined. In this ship provision has been made for the possibility of one of the gasbags becoming deflated, a condition which would lead to excessive stresses in the bracing wires due to lateral loading from the gas pressure in the adjoining gas bags, and this, in turn, would produce heavy stresses in the main frames. The difficulty, however, is partly met by the provision of a central longitudinal wire connecting the flat ends of each gasbag and tying them together. The outer cover is composed of strong linen fabric coated with a special weather-resisting dope before application to the airship, and a further doping when in position, to render it as tight as possible. Both the framework and outer cover are specially stiffened in way of the slip streams from the propellers.

There are five cars, or gondolas, in all; what appears, in Fig. 2, to be a single forward car being really two cars placed one closely behind the other. The foremost of these two cars is used exclusively for navigation purposes, while all the others contain the engines. These are Sunbeam "Maoris" giving 270 h.p. each, and five in all are carried, giving the ship a maximum speed of 55 knots in still air. One of the engines is mounted in the car immediately behind the forward navigating car, and one each in the two wing cars amidships, shown in Figs. 1 and 2. These three engines each drive 16-ft. propellers on the rear of the cars through reduction gearing having a 2 to 1 ratio. The after car carries two more engines, which are placed *en échelon*, and together drive a single propeller, about 19 ft. in diameter, through a reduction gear-box. This car is also fitted so that it may be used as a secondary navigating station if necessary.

The internal keel, best shown on Fig. 6, page 84, is used as a corridor, and in it are placed all the fuel-storage tanks, water ballast bags, and bomb racks; it also forms the crew's quarters. A considerable number of the fuel tanks are slung on slip attachments arranged so that they can be discharged, in addition to the water ballast, if necessary, for lightening or trimming the ship. All the gasbag manœuvring valves, previously referred to,

as well as the water ballast bag valves and the releases for the handling and mooring ropes, are operated from the commander's station in the forward control car. The rudders and elevators, which are well shown in Fig. 1, are, of course, also controlled from this station. Both can be moved through an angle of 20 deg. on either side of the mid position, but as they are aerodynamically balanced, the effort required to move them is comparatively slight. They are operated by steel wires from the control station, and the arrangements are such that the top and bottom rudders, and also the port and starboard elevators, can be worked independently. The elevators can also be fixed in the mid position, if necessary, to facilitate any running repairs to the gear. Auxiliary controls are led from the main control leads into the after car, which, as previously stated, forms a secondary navigating station. It is fitted with an exact duplicate set of control gears, and provided with a compass, so that the whole work of navigation can be carried on from this car. The ship is lighted electrically throughout by current supplied by generators run off the main engines, or from accumulators carried in the cars. There is also a complete telephone and voice-pipe installation. The wireless apparatus carried is of the latest type, and has ranges of 500 and 1,200 miles; directional wireless apparatus is also installed. Special attention has been given in the design of the ship to the questions of mooring and handling equipment. The arrangements are illustrated in Figs. 5 and 6 on page 84, and it will be seen that a very complete set of hauling-down ropes has been provided for controlling the vessel when landing. A drogue, for mooring the airship at sea, will also be noticed, and we may add that an arrangement has been incorporated in this by which the vessel can be anchored on land. In both cases a tripping gear is fitted which enables the mooring to be slipped instantly if necessary.

The R.34 was completed towards the end of last year, and her first formal trial lasted just over four hours. Afterwards a special endurance flight was undertaken, and on this occasion she remained up throughout the night for a total period of 19 hours. This flight was made from the banks of the Clyde, down over Ireland and the West Coast of England, and back again. The official acceptance trial also lasted overnight, but this was due to the fact that fog prevented a landing at her station, East Fortune. The ship was actually in the air for 20 hours on this occasion, and proved thoroughly reliable and satisfactory; it was easily and safely housed after the fog had dispersed. After being handed over to the Admiralty, the vessel carried out a very notable long-distance flight over the German coast and the Baltic. On this occasion she left East Fortune on the evening of June 17, and returned in the early hours of the morning of the 20th, after having been in the air for 56 hours and covering some 2,400 miles.

We may conclude our account of the airship by giving a few particulars of the recently-completed double journey across the Atlantic. The airship left the Admiralty Station at East Fortune, near Edinburgh, at 1.48 a.m. G.M.T. on Wednesday, the 2nd instant, and, travelling *via* Newfoundland, arrived at Mineola, Long Island, at 2 p.m. G.M.T. on Sunday, the 6th instant. The intervening distance of about 3,600 land miles was thus covered in 108 hours 12 minutes, which gives an average speed of 33¼ m.p.h. Throughout the outward trip the weather was unfavourable, the sea and sky being only seen on comparatively rare occasions. High winds were encountered, and a storm lasting some 30 hours was entered when the airship was only 600 miles out. This necessitated the use of all the engines at full power, and considerably reduced the petrol supply, as also did further bad weather experienced off the coast of Newfoundland. As a result of this some anxiety was felt as to whether the vessel would be able to complete its journey to New York, and wireless calls for assistance were sent out on the 5th instant while travelling down the coast of New Brunswick and Maine. Weather conditions, however, improved, and the ship reached its destination under its own power, as above stated. The only mechanical difficulty experienced on the outward journey was the cracking of a water jacket on the starboard amidships engine, which occurred on the 3rd inst., and was temporarily repaired. The quantity of petrol taken on board at East Fortune is given as 4,900 gallons, and we are informed that the total capacity of the tanks is 5,800 gallons. The former quantity would, doubtless, have been ample for the outward journey, and for a considerable portion of the return trip, had the weather conditions not been so consistently unfavourable. As it was, the petrol supply in hand at the end of the outward journey would only have lasted another 40 minutes. Shed accommodation for such a large airship not being available in America, the vessel was moored in the open, so that it was necessary to commence the return journey as soon as possible. After filling the tanks with petrol, and making good the loss of hydrogen, the vessel started back at 3.54 a.m. G.M.T. on the 10th inst., first circling over New York City for about an hour. The conditions for the return journey were much more favourable at first, and on one occasion a speed of 83 miles per hour was recorded with only four engines working. The journey continued usually at a height of about 3,000 ft., without particular incident until the morning of the 11th inst., when the forward engine of the two in the aft car broke down in such a way that it could not be repaired. This, of course, reduced speed, and further trouble was experienced on the next day owing to broken valves on the aft engine. This, together with a N.E. wind, reduced speed to 28 knots. However, the vessel crossed the Irish coast a little to the north of Clifden at 8.10 p.m. on the 12th inst., and the journey was finally completed at Pulham, in Norfolk, at 6.57 a.m. G.M.T., on the 13th inst. The total time of the return journey was thus 75 hours 3 minutes, and the distance travelled about 3,450 land miles. The mean speed works out at 46 miles per hour. It may be added that the airship commander, Major G. H. Scott, was instructed by wireless to return to Pulham, instead of to East Fortune, as the weather conditions at the latter station were considered dangerous.

We have thus been able, in the short interval of four weeks, to record the successful crossing of the Atlantic by aircraft both of the heavier-than-air and lighter-than-air types. It is a source of considerable satisfaction that both machines were the products of British brains and labour, and that they were piloted entirely by British officers and men. Although the flight of the Vickers-Vimy aeroplane was by far the more difficult feat of the two, the double journey of the R.34 seems to us to be of more immediate importance, in that it will furnish valuable data for use in the design of airships, which we regard as the more suitable type of aircraft for long oversea journeys under commercial conditions. We, therefore, offer the officers and men of the R.34 our congratulations on their splendid achievement, and with them must be included the vessel's designers and constructors, whose efforts rendered the journey possible.

THE LATE DR. JOHN INGLIS.

WIDE regret will be entertained at the announcement of the death of Dr. John Inglis, a well-known Clyde shipbuilder, which took place on Sunday last at his son's residence at Ayr, where he had gone for rest and change. He was one of the pioneers in scientific shipbuilding, and even to-day, with a wider knowledge and broader application of theoretical and mathematical principles, his early work stands out as a guiding and stimulating influence. Equally effective in the development of trade was his knowledge of economics and his just, yet firm, advocacy that they must have dominant influence in the relations of capital and labour. His trenchant pen was often used with considerable success in advancing these two necessities to industry. His words were forceful, his epigrams apt, and a tendency to sarcasm, which was characteristic of his writings, was always relieved by the dry humour typical of his race and by the convincing accuracy of his arguments. His sterling honesty was above all his traits of character, and if he showed impatience it was against self-seeking and self-advertisement.

The subject of our memoir was born on July 16, 1842, the eldest son of Anthony Inglis, who founded the firm of A. and J. Inglis in 1837 and was joined ten years later by his brother John. The beginnings were modest, the work being ship's smith work, and it was perhaps only a coincidence that the more important work of building ships was commenced after the son of the founder joined the firm. He was educated for the engineering profession, gaining a sound grounding, first at the Glasgow Academy, entering, when 15 years of age, the Glasgow University, when it was located in the old college buildings in the High Street of Glasgow. Here he had the advantage of being under the brothers Thomson—James of water turbine fame and William (later Lord Kelvin)—Lord Lister, Macquorn Rankine, Blackburn and others whose names are now historical. It can be well understood that on a youth with great perceptive power and latent desire for knowledge the influence of these giants in science had a lasting effect. Moreover, those were days of strenuous life. The age of the students was indicative of the spirit of the times, and as transport facilities were limited, a long walk before 8 o'clock in the morning was a usual exhilarating beginning of the day. Inglis proved himself an apt mathematician with a strong bent for mechanics, but his curriculum was by no means limited, as is too often the case, to vocational study. His father was a man of broad sympathies, and, as a consequence, natural philosophy and the arts were accepted as desirable subjects in the cultivation of the mind for the tackling of bigger affairs of life. Thus, it came that while young Inglis entered the firm's Warwick-street Works with a strong penchant for the mathematical solution of problems, he could take a sympathetic view of the rough and ready, yet wonderfully accurate, methods adopted by the workers, and even then, although he had not reached his majority, he realised that the new scientific solutions were only methods, in many cases, of establishing the bases from which intuitive knowledge had, by rule of thumb, attained comparative success.

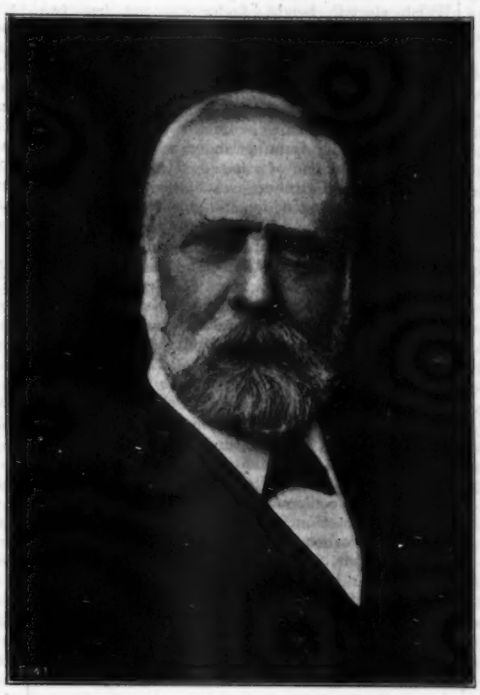
He entered the works when 17 years of age, and served some time in each of the departments, but for a year or two he continued his study at the University. For a time the firm had confined themselves to engineering. The first important marine contract was entered into in 1850, and was for the machinery of the Clyde Trustees' tug, the Clyde. It is a proof of the soundness of the work done that this vessel continued running with her original engines for 62 years, and in 1912, when the engines were taken out of the vessel, they were erected on the river front at the Burgh of Renfrew, by Mr. William Brown (of Messrs. William Simons and Co.), whose father was manager for Messrs. Inglis when the engines were constructed. The machinery for what is believed to be the first screw steamer to cross the Atlantic, was built in 1855. In 1862, two years after young Inglis joined the firm, they started shipbuilding at Pointhouse. Young Inglis had been a student of naval architecture, and his training as an engineer was an admirable preliminary to his training in shipbuilding, and, therefore, he won his position as manager of the shipbuilding yard at 25 years of age.

It is not our purpose to review in chronological order the work done by the subject of our memoir, but one or two trends may be indicated. In his earlier years he was a keen yachtsman, and had great delight in designing, building and racing vessels of this class. This naturally led to the firm specialising in yachts, not only of the sailing type, but of steam craft. He was the first to build a yacht (his own Hilda, constructed in 1871) with a broad wooden keel and a heavy leaden one, now universal in racing boats, while for beauty of form and thoroughness of finish of all parts of hull and machinery his vessels have been widely recognised by authorities as the finest examples of this work. Many orders came to the firm from those who recognised the value of the work done. The story is told of an Irishman who arrived at the works on a Saturday, and left with Mr. Inglis a cheque with the request that a yacht should be built as good as an Inglis boat he had bought and afterwards sold. There was no other contractual document and the last instalment for the yacht was a blank signed cheque. Two other yachts were built for the same

owner on similar terms, and the circumstance is a tribute to Inglis as a yacht designer, and as an upright man of business. Amongst the other clients was the Khedive of Egypt, for whom the famous Safa-el-Bahr, a vessel of 670 tons, was built in 1894. It was largely as a consequence of experience with this ship that the Khedive's yacht Mahroussa, an old paddle steamer of 3,600 tons, built in 1865, was sent in 1906 to Inglis' yard in order to be reconstructed as a turbine-driven screw steamer. But Kedivial recognition had come earlier, Mr. Inglis being decorated as Commander of the Imperial Order of the Osmanlis. Mr. Inglis' design, too, was accepted by King Edward for the Royal yacht, which ultimately was named the Alexandra. This vessel was built in 1905–6, and is still in high favour amongst the Royal yachts.

Dr. Inglis' scientific tackling of problems resulted also in great success in the building of light-draught river steamers, and the Erl King, one of the first steamers constructed for the China service brought the firm much work from the Far East, as the vessel made a splendid voyage to the East in the days before the Suez Canal linked the Red Sea with the Mediterranean. At that time the river steamers in China were built in America and were of timber, large numbers of the "walking" engine beams being of the same material. The Shanghai Steam Navigation Company placed a trial order with the Inglis firm for a steamer of the American type, but with iron hull and iron engine framing and walking beam. The ship proved a great success, and from this time onward America lost her supremacy on the China rivers. This was also the case with the River Plate. Many of the light-draught Clyde steamers, too, have been built at Pointhouse, while for the Channel service, Inglis built a large number of moderate-speed vessels, where the difficulty in design was associated with a relatively large cargo capacity and minimised length to suit docks. The ocean ships designed by him were equally notable, not so much for their high speed as for their propulsive efficiency. The art of shipbuilding is too often measured by the size and speed of the steamers built, whereas other important standards are the minimum resistance, engine economy, and combined efficiency of machinery and propellers. All these received due care from Dr. Inglis, and the result was the reduction in expenditure per 100-ton mile in the transport of cargo. Soon after he became manager of the Pointhouse Yard, he formed an association with Mr. (afterwards Sir) William McKinnon, of the British India Steam Navigation Company, and seldom was the Pointhouse Yard without one or two B. I. boats. The friendship and easy business association continued throughout the life of Sir William McKinnon. Similarly, with other companies, life associations were maintained. Long before the principle of similitude was accepted under that title, Dr. Inglis worked upon it with great success. He was amongst the first to adopt the principle of progressive speed trials on the measured mile and of careful study of the results achieved. He was early, too, in his public advocacy of this system of determining the resistance of ships, and, with the late Mr. William Denny, of Dumbarton, was associated with Dr. Froude's method of tank experiments with models of different forms and with comparative screw propellers. He was the first shipbuilder on the Clyde to carry out experiments by inclining vessels when completed in order to determine their stability and to assist towards accurate loading. He was also a pioneer in the determination of longitudinal stresses in the hulls of ships. He conducted many experiments on a practical scale, one of the more interesting having reference to the relative strength of bulkheads built with independent angle stiffeners, and with the edges of the plates flanged to form the strengthening medium.

Dr. Inglis was associated with many of our technical institutions. He was vice-president of the Institution of Naval Architects. He was president of the Institution of Engineers and Shipbuilders in Scotland in 1893, and of the Institute of Marine Engineers in 1898. He wrote many papers, but only rarely took part in the discussions. He was wont to say that he could think better with the pen in his hand, but when he did speak, he was exemplary in the value of the information imparted relative to the time occupied. His speech was as direct as his writings, and was embellished with originality of words as of thought. The Royal Philosophical Society of Glasgow offered him a splendid platform for contributions on economic questions, and some of these were memorable, notably, the one on the apprentice question, in 1894. Equally important was his condemnation of the Workmen's Compensation Act in 1897, in a paper to the Civic Society of Glasgow. As we have already said, he was firm but just in all economic discussions, and it is remarkable that, during his presidency of the Shipbuilding Employers' Federation in 1905, he won the respect of labour leaders for his impartiality and straightforward honesty. Although author of one or two brochures, his only notable book was "A Yachtman's Holiday," and in this he found full scope for the exercise of his rich vein of humour for a display of his gifts as a *raconteur* and an analyst of human nature.



Yours faithfully
John Inglis

Notwithstanding his complete control of the works, he found time to devote to the advancement of many of the national organisations and institutions in Glasgow. He served on several Royal Commissions and committees, notable among which were those on the water-tube boiler and on the strength of torpedo-boat destroyers. He was a member also of the Board of Trade Advisory Committee, and served for a time on Lloyd's Registry Technical Committee. One public post which gave him great pleasure was his membership of the Clyde Navigation Trust, and he was well fitted to be convener of the Workshops and Mechanical Appliances Committee. He was also one of the Clyde Lighthouse Trustees and for many years a director of the North British Railway, of the Glasgow Chamber of Commerce, of the Merchant's House, and of St. Mungo's Medical College, while he was also a Governor of Anderson's College Medical School.

His great recreation was music. He was an admirable executant on many instruments, and had a magnificent voice, which was a delight to the members of the Institute of Marine Engineers, when, at their annual dinner during his presidency, he sang the "drinking song." Indeed, his whole family were musical, and it used to be said of them that they could give amongst themselves a complete orchestral concert. He was for many years chairman of the Executive of the Glasgow Choral and Orchestral Union and honorary president of the Glasgow Choral Union, devoting much time and great experience and knowledge to their concert programmes.

In 1898 his friends were delighted at the decision of the Senate of the University of Glasgow to confer upon him the honorary degree of LL.D. The reasons given by the Senate is a fit epitome of his work: "He had always manifested the deepest interest in the scientific side of his profession, and the papers contributed by him to the various societies with which he was connected have shown him to be at once a capable thinker and graceful writer. But his sympathies were not bounded by his profession; he was well-known for the support he gave to the cultivation of music in Glasgow, and his keen interest in social and economic questions."

Dr. Inglis was married in June, 1867, to a daughter of the late James Denny, shipbuilder, of Dumbarton, and celebrated his golden wedding in June, 1917, when the staff and other employees of the firm seized the opportunity of showing their great respect for both Dr. and Mrs. Inglis. Of his six sons, four are associated with the firm; the eldest is a medical practitioner, and the youngest an advocate in Edinburgh. Mrs. Inglis, who survives him, and her sons, may be assured of the great sympathy of a wide circle of friends.

The funeral took place at the Necropolis in Glasgow, on Wednesday last, on his 77th birthday.

LARGE FERRO-CONCRETE BRIDGE.—The recently-completed ferro-concrete bridge over the Ore River in Sweden, has an arched span of 90·7 m. It belongs to the northern railway system of the country, and crosses the river about 4 km. to the north of the town of Nyaker. There was a parallel-girder bridge at the place, built in 1891 and calculated for axle loads of 12·5 tons and speeds of 20 km. per hour. The new bridge can bear axle loads of 20 tons at speeds of 100 km., and belongs to the longest ferro-concrete bridges in existence, the one over the Tiber at Rome, having a length of 100 m., and the Auckland bridge in New Zealand, a length of 97·5 m. The cost was estimated not to exceed 850,000 kroner in 1914, but owing to the war, the expense will probably amount to 2,100,000 kroner.

THE NATIONAL PHYSICAL LABORATORY.

(*Continued from page* 36.)

Electricity Department (Superintendent, Mr. F. E. Smith, F.R.S.).—The various, more or less separate, electric divisions of the former Physics Department have been united in an Electricity Department, of which Mr. F. E. Smith has been appointed superintendent. The transfer of the electric standards and of the meter-testing work from the Board of Trade to the National Physical Laboratory made a concentration of the electric divisions desirable, all the more as the development of radiotelegraphic researches has brought the fundamental and high frequency work more in close touch with alternating-current work. The standard instruments from the Board of Trade have now been erected on concrete pillars; it cannot be questioned that they crowd the other apparatus, and further space will have to be provided for high-frequency and magnetic researches. The hut erected for such work is only a temporary building, which will hardly suffice. The battery has not been received from the Board of Trade, and the instruments are not yet in working order.

There have been changes in the staff. Mr. A. Campbell, one of the original members of the Laboratory staff, has retired; Mr. C. C. Paterson and Dr. Norman Campbell have left, and the staff of the two divisions of the new Electricity Department under Mr. F. E. Smith consists now of: General Measurements, electric and magnetic, including standards and radiotelegraphy: Messrs. J. W. Dye, S. Butterworth, Smith-Rose and Hartshorn; Electrotechnics, including photometry: Dr. E. H. Rayner, M.A., Messrs. S. W. Melsom, A. Kinnes, McLachlan, J. W. T. Walsh, H. C. Booth, Buckley, Spilsbury and Miss V. Cockburn.

Fundamental Units and Radiotelegraphy.—There is little to be said about the largely confidential work of this division; even the demonstrations given on the day of the inspection were restricted by this consideration. Some of these, on three-electrode valve sets, for producing oscillations of audible frequency, were mentioned in our article on the Royal Society Soirée,* held in May last, where they were also shown by Mr. F. E. Smith. In the reception of continuous waves by the heterodyne method the valves act as transmitters. The transmitting apparatus consist of a tungsten valve filament in circuit with a battery of 6 volts; the valve grid or spiral in a branch circuit comprising the grid coil and a variable condenser in shunt to it; finally, the valve cylinder in circuit with the anode coil (parallel to the first), another variable condenser in shunt to it, and a battery of 100 volts; all the three circuits are connected. In ordinary radiotelegraphy an aerial would further be wanted, the coil of which would react on the anode coil; in heterodyne, as demonstrated, receiving no aerial is required. The receiving apparatus is the same as described, but the two instruments are purposely not tuned to the same frequency. Supposing the frequencies of the two instruments are 60,000 and 61,000; the listener on the telephone then hears the differential beat-note of frequency 1,000; that note will be too high for some ears, and the advantage of the method is that the operator can at once tune his instruments for a lower note that suits his hearing.

Capacity and Frequency Magnetic Work.—Ordinary testing of frequencies, inductances and of magnetic properties have left little time for research. In the accurate measurement of capacity at low frequency, use is made of the Carey Foster bridge and of Campbell's moving coil galvanometer, which only makes ten vibrations per second, *e.g.* The theory of the vibration galvanometer, which acts on the resonance principle and replaces the telephone in many bridge measurements, had been perfected by Mr. Butterworth some years ago, when he also explained the application of this galvanometer, for instance, for comparing a small inductance of the order of a few milliheuries with a capacity of 0·1 microfarad. How capacity can be measured in terms of mutual inductance at high frequency, had been shown by Campbell in 1908. This method is also very useful for determining frequency by the aid of a known condenser and a variable mutual inductance. In the simplest form of the apparatus the mutual inductance m is joined in a closed circuit with the source of frequency n and a vibration galvanometer, and the condenser k is placed in a shunt from the split inductance over to a point between the galvanometer and the source; the mutual inductance is adjusted until the galvanometer (or telephone) shows no current; then $m\,k\,w^2 = 1$, where $w = 2\,\pi\,n$. Demonstrations of this and other measurements were given.

Electrotechnics.—Most of the work of this division has also been confidential for the Air Board and other Government Departments; magnetos alone have claimed a great deal of time. In the demonstration of insulator-testing for high-volt transmission under artificial rain, the fixed insulators were exposed to a dense spray of water, and were flashing through gaps of 1 ft. or 2 ft., while carrying currents ranging from 50,000 volts up to 100,000 volts. The information given on the Paterson-Walsh electric height-finder was not free from restriction. An essential part of these height-finders is the sighting plane; two wire rectangles are so mounted in parallel planes about 1 cm. apart, that the observer can sight a distant object, a star or flying machine, *e.g.*, by looking through the slots between the two wires. If two such planes, each turning with its framing about a horizontal axis, are fixed at the end of a base, say a mile in length, the height of the object can be deduced from the elevation angles at which the object appears to the two observers. That principle was suggested simultaneously by the late Lieut. Mansell-Pleydell and the late G. T. Bennett, F.R.S., and the principle may be utilised in various ways. The first mechanical, very simple instrument adopted early in 1916, was that of Dr. Rayner, at that time attached to the Munitions Inventions Department; it was designed for use at night only, and for ready construction in an engineering workshop, but was superseded by the more automatic instrument of Messrs. Paterson and Walsh. In this instrument a contact arm of phosphor bronze moves in unison with the sighting plane, the table of which is inclined more or less with the aid of handle bars; the arm turns about a pivot in the continuation of the axis of the plane, and in this motion the arm rubs against the convolutions of a rheostat, which is wound on a straight horizontal bar, the pivot mentioned being in the centre of the bar; this whole portion is immersed in an oil bath. As the plane is raised or lowered, the point of contact between the arm and the rheostat changes, and with it the resistance in circuit between the centre and the point of contact. The two observing stations are connected by a cable, electrically in series, and the elevation angles are deduced from the observation of voltmeters. There is a battery at each station, in series with an auxiliary resistance to adjust the battery potential. The cable includes a telephone wire; there is also a button at the lower end of the plane handle of each instrument, by means of which the attention of the observer at the other end is attracted and communications are exchanged. The two instruments have, in the first instance, of course, to be set with their sighting axes as parallel as possible within 0·1 deg.; this is attained by means of astronomical instruments or by survey.

The apparatus designed by Mr. Walsh for testing radium-painted dials, was described on page 61 of our issue of January 19, 1917; it has since been improved. It is a photometric device; the dial to be tested is placed between two artificial dials, which are cut with a stencil to correspond to the dial, and are illuminated from behind through a green filter to make the light of the stencilled letters and numbers the tint of the radium-painted symbols; the illumination is varied until the artificial dials appear of the same brightness as the real dial between them. The observations are repeated after having exchanged the dials on the left and right. Many thousands of dials have been tested in this way, and different observers generally agree.

The cubical integrating photometer box mentioned last year (August 2, page 122), has recently been used for testing searchlight lamps, and particularly the Harrison arc lamp, which gives 120,000 candles. In this lamp the two carbons are not quite in alignment, the one being horizontal, the other sloping up to it at an angle of about 150 deg.; at right angles to the vertical plane of the carbons are mounted two tubes, through which alcohol vapour is blown into the arc; the electric pump sending alcohol up the two tubes is in shunt to the arc current. The alcohol prevents the rapid combustion of the carbons, and seems also to cause the formation of a cushion of incandescent vapour; the alcohol consumption amounts to about 1 pint in 1¼ hours; the carbons are impregnated with cerium chloride. With the aid of a hole in the box an image of the arc is reflected on to a scale outside so that the arc-length can be measured in connections with the photometric measurements.

Continuous Currents. Cable Research. Manganin (Messrs. Melsom and H. C. Booth, Miss V. Cockburn).—The high-tension testing of cables in the cable hut has been interrupted because the motor-generator set specially ordered for this research did not arrive in perfect condition, and the required alterations were delayed. Cables for 20,000 volts, for Glasgow, are lying on the floor of the Laboratory, waiting for the complete installation of the machinery. The heating effects of the dielectric are to be investigated, as well as the heating from the core losses; large differences in the thermal constants of various dielectrics have been detected in cables from different sources of supply. Very satisfactory progress has been made with the manufacture in the Laboratory, from start to finish, of manganin; the work is done in collaboration with the Metallurgy Department, and the chief difficulty is in the drawing and annealing of the ¼-in. rods made.

Heat. Heat Insulation for Cold Storage. (Dr. Ezer Griffiths, Mr. E. H. Schofield).—Special apparatus have been designed with a view of obtaining data for the heat transmitted through the walls of cold stores when insulated with cork, silicate of cotton, charcoal, &c. These materials possess large temperature coefficients, and the experiments must be conducted over the actual temperature range required. The apparatus consists essentially of a hot plate (a large electrically-heated plate, 3 ft. diameter), supported between two cold plates (cooled by brine coils); the material under test is sandwiched in between the plates in the form of a uniform layer from 3 in. to 8 in. in thickness. With the aid of the special winding adopted for the mat of asbestos-covered wire, uniformity of temperature is attained over the hot plate, the variation amounting to less than 0·2 deg. over the entire area. The flat guard ring, 1 ft. in width, surrounding the hot plate in the same plane, is maintained at exactly the same temperature. Heat losses from the edge of the hot plate are hence avoided; the corrections otherwise required for heat losses cannot accurately be determined, and as the magnitude of the correction increases with the thickness of the layer tested and amounts to 30 per cent. in the case of 8-in. layers of insulation, this is an important factor. The cold walls consist of two stout steel plates, 6 ft. by 6 ft.; the steel surfaces have to be made plane within 0·001 in.; the brine coils at the back of the plates are lead tubes, square in section, wound in bifilar fashion, the inlet and outlet pipes being adjacent and jointed together at the centre, so as to ensure uniform temperature distribution. About half a mile of lead piping is coiled on these plates, which weigh ½ ton each. The hot and cold plates are suspended from a girder frame work at any desired distance apart. An ammonia refrigerator of Messrs. J. and D. Hall and several brine tanks further belong to the equipment. Temperature measurements are made with the aid of numerous thermocouples and of electrical distance thermometers, the latter having been presented by the Cambridge Scientific Instrument Company. When working at the lowest temperatures of — 20 deg. C. for the cold faces, the plant has to be run continuously at its maximum capacity, and a temperature uniform within 0·25 deg. can be maintained for 24 hours. The experimental determinations require uninterrupted runs of from 10 to 14 days, as it takes a long time to set up uniform temperature gradients.

* See page 710 of our issue of May 30 last.

For the investigation of the transmission of heat from and to surfaces, very sensitive forms of anemometers have been devised to map out these convection currents near warm walls. The velocity of these currents is of the order of a few inches per second, and thus below the sensitiveness of a Pito tube or any convenient form of gauge. The anemometer consists of a fine platinum wire, which is stretched across an elastic bow of wood and suspended from a kind of Atwood fall machine, so as to glide down in front of the wall under test at a definite speed; the resistance of the wire gives the temperature. The determination of the humidity in cold stores is another problem which Dr. Griffiths is investigating; the ordinary wet and dry bulb are worthless at low temperatures, and the moisture-content is of importance in the preservation of fruit, which is apt to shrivel in too dry an atmosphere. Dr. Griffiths finds that the refractive index of a film of glycerin seems to change sufficiently with the humidity of the atmosphere for basing a method of humidity determination on the measurement of this index, which is easily effected by means of an Abbe refractometer; a distant-reading hygrometer would be a valuable addition to our instruments. The thermal conductivity of frozen meat is also under investigation. These researches are being conducted for Panel D. (Heating and Cooking) of the Engineering Standards Committee, and an account of the results is soon to be presented to the Institution of Electrical Engineers.

(To be continued.)

LITERATURE.

(1) *Elements of Graphic Dynamics: An Elementary Text-Book for Students of Mechanics and Engineering.* By EWART S. ANDREWS, B.Sc.Eng. London: Chapman and Hall, Limited, 1919. [Price 10*s.* 6*d.* net.]

(2) *Notes, Problems, and Laboratory Exercises in Mechanics, Sound, Light, Thermo-Mechanics and Hydraulics, prepared for Use in Connection with the Course in Natural and Experimental Philosophy at the United States Military Academy.* By HALSEY DUNWOODY. New York: John Wiley and Son, Inc.; London: Chapman and Hall, Limited, 1917. [Price 13*s.* 6*d.* net.]

(1) MR. ANDREWS' book is admirable both in execution and design. Its main purpose is to show that graphical processes, based on the laws of fundamental dynamics, can be usefully employed in analysing and solving engineering problems, on lines analogous to those employed with good effect in "Graphic Statics." The same reasoning and educational mechanism do not serve equally well for all students, and it is evidently desirable to open as many avenues as possible. Those students to whom algebraical symbols and formulæ suffice need not be disturbed; they can tread the stereotyped paths contentedly; but there are many to whom the appeal to the "faithful eye" by means of diagrams is at once convincing and effective. This is the class now addressed. No attempt is made to suppress tried and recognised methods of instruction. But if alternative methods make progress more rapid, remove difficulties from the path of some, or make the way more attractive to others, such devices should not be neglected. The author evidently holds strong views on the educational value of graphical processes, and we are inclined to agree with him. The champions of the mathematical method of argument have, and do, attach great importance to its value in the development of reasoning powers and they are right, but it should be remembered that mathematical analysis is the only plan of instruction that has been widely tried, and that experience is limited to watching its effect on the successful. Of those who drop out by the way, because they cannot overcome the difficulties of the road, the leaders of educational opinion know little or nothing.

The author suggests quite correctly, that the same consecutive and methodical plans that have won for "Graphic Statics" a recognised place in the educational curriculum, have not been pursued with equal vigour in dynamical problems, and in this book he makes a serious attempt to remove the defect. He erects a scaffolding on which others can build, for though it is the student that he has mainly in view, the processes described are available in other directions where greater complexity prevails. By adopting the steps indicated, the expert engineer may shorten the labour involved in the heavy computations which often face him, or detect an adequate solution to some problem arising in actual work.

The earlier chapters explain the construction of various curves which are to serve as the machinery for solving various kinds of problems. The "space curve," the "velocity curve" and others are devices that cannot fail to attract by their ingenuity and geometrical significance. Perhaps in some cases, a little fuller description would have avoided some ambiguities. We imagine that a student, for example, would have some difficulty or uncertainty in comprehending what is meant by "the area of a curve" or fail to see how an ordinate could represent an area. On the other hand, he would probably enjoy the escape from a differential coefficient by a graphical construction, and obtain possibly a clearer insight into the reasoning than others who regard the ordinary notation, simply as a symbol of operation. It is to be feared that some handle the machinery of the calculus very deftly, obtaining correct solutions to problems, but fail to grasp the underlying thought, just as one may use a book of logarithms without understanding the principles on which they are calculated. But the correct solution is regarded as the satisfying criterion. The numerical accuracy may always remain with the adherent to algebraical rules, for when it becomes necessary to draw a tangent to a curve a very considerable error is possible, "for no graphical construction is known which is really more accurate than drawing a line by eye to touch the curve."

In the fourth chapter, vector notation is introduced in connection with polar diagrams, when it is convenient to represent a quantity as measured by the angle the radius vector makes with a base line and another quantity by the distance measured along the radius vector from the origin. The application of such diagrams to simple harmonic motion, or the method of analysis suggested should interest the student by the novelty and simplicity of the results. The design and motion of slide valves for steam engines, cams, and other mechanism capable of affecting small intermittent movements of some of the parts, afford ample opportunity for applying the theories to practical work. Judicious use is made of such aids to arouse interest and excite ingenuity.

In the combination of velocities, the employment of vectorial notation shows to advantage, and we imagine that many who have never heard of vectors have unconsciously employed the method. If an example were needed we might select one of the many illustrations with which the author enriches his pages and enforces his reasoning. "If a train is running at 44 ft. per second, in what direction must a stone be thrown at a velocity of 60 ft. per second to pass in through one open carriage window and out through the opposite window?" There are forms of mind that solve such problems intuitively, they visualise the path of the projectile and are unconscious of any mental effort, but if the successful process of solution were analysed it would probably be found that they had seized the essentials of a vector difference. It is for such as these we conceive that "Graphic Dynamics" is written. Others who find an algebraical formula as informative and satisfactory will adopt the methods that appeal to them. "We are not forced to employ in our calculations graphic methods when numerical substitution in a formula will be more convenient" is the author's answer to those who want accurate arithmetic. There is another class who would stop to ask what is the width of the carriage; these, too, have to be catered for, but in another way.

The hodograph is another device whose practical value has been recognised without any very definite notion of its elementary relations to a change in the direction of velocity. It is usefully introduced here, among other ways, in explaining the true meaning of "centrifugal force." The author does not say explicitly, that there is no such force, though he might have done. He makes it clear, however, that the term is employed only to express the reaction on the axis of the centripetal force, or a balancing of the system of forces acting on a body. The numerical illustrations are, however, worked out from an algebraical formula rather than by measurement from a diagram.

The theory of linkage and the designs for crank and connecting-rod mechanism offer good opportunities for illustrating the advantage of graphical construction. Some of the demonstrations have long been known, that of the Rittershaus and Elliott construction are familiar instances, but they gain in force and suggestiveness by direct comparison. They are, too, well adapted to educational purposes, as the appeal to general principles is close and necessary. The author has known how to cover some well-worn ground in a novel and refreshing manner, and we trust that the methods indicated here will be applied to more subtle and complicated examples.

(2) THIS book is very well described in the title, and the contents present few novel features. From the short preface, it appears that the treatise has been prepared so as to form a ready reference to the subjects covered by the department. The preparation has been entrusted to the competent hands of Professor Dunwoody, who received instructions from the United States War Department to revise the course of instruction in Natural and Experimental Philosophy at the Military Academy. Able colleagues have cordially collaborated with Professor Dunwoody, and a manual that satisfies existing requirements is the result.

Apparently, owing to lack of time, it had been found difficult for a student to refer to a subject under study in any other source than his text-book. Hence the necessity of making that text-book as complete and serviceable as possible, and it is believed that by consolidating the matter, an essential improvement has been effected. Also an extension has been made in the matter of practical work. Previously, it would seem, that the students at the Military Academy were not expected to undertake any experimental work in physics generally. But a period of one month's practical work has now been arranged for. The Worcester Polytechnic Institute has supplied a model, and the students should benefit by this course, short as it is. "Copies of the exercises to be performed by the students *themselves* in the *laboratory*" are given in the treatise. The italics are in the original, and it is this unusual emphasis that suggests that practical work under supervision is a new departure.

The notes on Mechanics have been prepared by Professor C. R. Cross, of the Technical Institute of Technology, Massachusetts. The "Notes" must consist largely of amplified definitions, further extended by illustrations. Considerable attention is given to problems connected with gravity, with various forms of pendulums, with the determination of g, and the figure of the Earth. The choice of problems suitable to a short course is of less importance than the manner in which they are treated. Here there is ample opportunity for acquiring thorough acquaintance with general principles, a broad and accurate survey of a wide subject, with incentives to prosecute further inquiry.

The problems on the composition and resolution of forces are mainly confined to a short section on "Graphic Statics," based on Gordon's "Mechanics," and Fiebeger's "Civil Engineering." The design and construction of roofs and framed structures afford examples for applying the principles derived. A large section is devoted to problems in mechanics, sound, light, thermodynamics and hydraulics. These problems are generally accompanied by notes to assist the student. The problems in physics are those in use at the Worcester Polytechnic Institute. The Rensselaer Polytechnic Institute supplies a series of elementary problems on sound, light and thermo-mechanics, while the scheme in force at the Massachusetts Institute of Technology furnishes a number of examples in applied mechanics. Finally, are presented problems in mechanics and hydraulics from the course in Natural and Experimental Philosophy of the United States Military Academy. Teachers will find here abundant material for increasing their standard examples, and we presume the incorporation of the approved work of so many different institutes will tend to a uniform standard. There is of necessity some repetition or similarity

in the problems selected from various sources on cognate subjects, but this can scarcely be regarded as a drawback.

Another main section is devoted to Notes on Translation and Rotation, following the treatment provided in Gordon's "Mechanics." These are, or should be, addressed to more advanced students, but the remark prefacing their introduction does not sufficiently explain their inclusion. Colonel Gordon's treatment of the subject, we are told, is more complete than the discussions in most text-books for use by students. "It is, therefore, included as a reference, although not forming a part of the present course." The book has been hurriedly compiled to meet a pressing local need; not having experienced the necessity, we are hardly in a position to understand what steps were required to meet the want, or how far the want has been legitimately met.

The exercises to be performed in the laboratory are prefaced with a comment that seems apologetic. It is admitted that practical exercises constitute an innovation, but it is not intended that this innovation should diminish the theoretical treatment, but rather that practice should proceed hand in hand with theory. It is feared lest the student, at the outset of his career, should have his attention diverted from the underlying mechanical principles to the derivation of a correct numerical result. "Precision measurements," it is suggested, should be reserved for an advanced stage in the student's career; it does not seem to be considered possible that the pupil might be given an intelligent interest in the method of operation, without making him an expert manipulator. The experiments here described are intended solely for the development of principles, and are not to be regarded as tests for precision. There are but 16 of these exercises, covering mechanics, acoustics, optics, &c., but these are considered sufficient to serve as guides for additional laboratory problems, required to meet any special set of conditions.

Catalysis in Industrial Chemistry. By G. G. HENDERSON, M.A., D.Sc., F.R.S., Freeland Professor of Chemistry, the Royal Technical College, Glasgow. London: Longmans, Green and Co. [Price 9s. net bound.]

ALMOST any reaction is now supposed to be subject to catalytic influences, and almost any substance, elementary or compound, is believed to be capable of serving as catalyst in some reaction, though the catalyst has to be selected for the particular reaction. But the term catalysis still masks our ignorance. The term is used to designate chemical changes, the progress of which is modified by the presence, often in minute proportions, of a foreign substance, the catalyst, which itself does not undergo any change in the sense that it is found chemically unchanged in the final products and remains thus capable of catalysing further masses of the reacting substances. There may be a change in the physical condition at the end of the reaction, and in many cases the catalyst (say platinum) undoubtedly acts by forming an intermediate, unstable compound with one of the reagents (oxygen), which is decomposed again and transfers its oxygen to the sulphur dioxide SO_2, to be oxidised to SO_3. But the catalyst is assumed only to accelerate (or to retard) a reaction without being able to start it—whatever that means—and it does not affect the equilibrium condition. Thus the oxidation of SO_2 by O to SO_3 in a mixture of the first two gases only proceeds to a certain equilibrium, a certain concentration of SO_3; when the limits of concentration temperature and gas pressure, upon which that equilibrium depends, are exceeded, the SO_3 will decompose again. The rate of the combination, however, can be accelerated to a surprising degree by relatively very small masses either of finely-divided platinum or of iron oxide. Now one can grasp that the platinum binds the oxygen to an unstable oxide from which the SO_2 is able to take the oxygen up, which, for some reason, it cannot do directly. But why should iron oxide (in practice cinders of roasted pyrites), generally a very inert substance, act as chemical oxygen carrier? The assumption seems more plausible that the oxygen is condensed on the oxide or adsorbed by it so that the SO_2 meets a more concentrated oxygen than it would otherwise do. When the hot glass walls of the reaction vessels, fragments of glass and firebricks, or the hot firebricks catalytically seem to promote combinations or surface combustion, the effect certainly appears to depend upon adsorption or condensation. Hence two catalytic theories are broadly distinguished, the chemical and the physical, though it will in many instances be very difficult to separate the physical from the chemical effect. We cannot oxidise and melt a lump of iron in a candle flame; finely divided the iron will easily melt in the candle, yielding incandescent globules of oxide. Most metallic catalysts are used in the finely-divided state, as spongy metals or, still better often, in the colloidal form, and the methods by which the chemical and physical reductions are effected are technically of signal importance.

Though chemically-related substances frequently have similar catalytic effects, chemists are by no means in a position to predict which catalyst will be most effective in any particular instance. The ways of catalysts are so bewildering, Professor Henderson says, that much careful experimental work is still required for each case. There are positive and negative catalysts, accelerating and retarding reactions, and catalysts may further be activated or impaired in their efficiency by "promoters" or "inhibitors." The product of a reaction may itself act as catalyst; thus the rate of the dissolution of metals in nitric acid increases with the evolution of the nitrous acid produced, and the rate of the hydrolysis of esters by water is similarly accelerated by the accumulation of the acid formed. Those cases are known as "auto catalysis." Sometimes one catalyst supports another. In the Bergius process of producing hydrogen by action of liquid water (not steam) at high pressure and temperature upon iron, addition of ferrous chloride $FeCl_2$ to the water raises the yield of hydrogen per hour from, say, 230 cub. cm. to 1,390 cub. cm.; the further addition of copper further increases the yield to 1,930 cub. cm., and when the temperature, so far 300 deg. C., at 300 atmospheres, is pushed up to 340 deg., 3,450 cub. cm. of hydrogen are obtained. Thus a vessel of 10 gallons capacity may give 3,000 cub. ft. of hydrogen per day, and the hydrogen is said to be very pure, because the liquid water does not attack the carbon and sulphur in the iron.* The reactions in this case cannot be simple; for one thing the electrolytic dissociation of water increases two thousandfold between the boiling-point and the critical temperature of water. We will not discuss the question whether it is necessary to distinguish the action of promoters (metals, alkali salts or hydroxides *e.g.*) from that of the catalyst proper (other metals), and to separate the "poisons" or "anti-catalysts" from the inhibitors. As little as 0·01 per cent. of sulphur in the iron catalyst spoils the synthesis of ammonia; Sabatier found that a trace of bromine in the air of his laboratory prevented the hydrogenation of phenol by nickel, and the profitable or baneful influences of many catalytic promoters and poisons have necessitated much laborious research, and have sometimes been revealed through lucky accidents rather than by investigation. We further consider the customary distinction of homogeneous and of heterogeneous catalyses as rather unfortunate in terminology. In homogeneous catalyses all the participant substances are in the gaseous state, or the reactions all take place in the same solvent; gas reactions into which solids enter (the catalyst being solid, *e.g.*) or reactions occurring in solutions to which solids or particles of colloidal metals or enzymes are added are considered heterogeneous. The introduction of solids and of emulsions, of course, makes the activity largely dependent upon the physical state; but the phenomena are still far too obscure, and there can hardly be real homogeneity in any case; yet the distinction is justifiable on grounds of convenience, if not on others.

Without diving at all into mathematics, Professor Henderson gives a clear and concise exposition of the principles of catalysis in his first chapter, and adds particulars about the preparation of some notable catalysts, nickel, copper, platinum, palladium, colloidal metals, &c. The use of colloidal solutions has greatly been facilitated by replacing the lysalbic acid and protalbic acid first used by gum arabic. More information as to the specific catalysts is contained in the various chapters on hydrogen, hydrogenation, ammonia and nitrogen, sulphur, hydration and hydrolysis, dehydration, oxidation and reduction, sulphonation, enzymes, &c. The multitude and diversity of industrial catalytic processes does not allow Professor Henderson in this volume of 200 pages to enter much into technical detail. There are no illustrations. What is given is thoroughly sound and instructive, and to the point, and will everywhere interest the reader. One hardly realises how great a part catalysis plays in chemical manufacture. The conversion of coke into graphite depends upon the presence of iron oxide or other oxides. Coal gas is freed of carbon disulphide and other sulphur compounds by being heated to 450 deg. C. in steel tubes in the presence of nickel (Carpenter's process). In a new German synthetic process nitrogen and hydrogen, compressed to 90 atmospheres, are heated to 600 deg., alkali metals or ferrocyanide serving as catalyst. The formation of aluminium nitride by heating alumina and carbon in an atmosphere of nitrogen (Serpek process) is accelerated by the presence of metals (iron, copper) or of oxides. As regards the Bucher process—chemically sound apparently—of preparing sodium cyanide with the aid of iron as catalyst, Professor Henderson draws attention to the serious mechanical difficulty of heating alkali carbonates and carbon up to 900 deg. C. The hydrogenation and hardening of fats and oils with the aid of nickel at about 200 deg. is generally connected with the names of Sabatier and Senderens; at ordinary temperature oleic acid can be converted into stearic acid by palladium or platinum black (Fokin and Willstätter). Since methane occurs in natural gas and forms an undesired by-product of oil cracking there might appear to be no demand for a methane synthesis; but gas rich in methane has a high calorific power and is very suitable for incandescent mantles, and there are several technical processes for the manufacture of methane from carbon monoxide and hydrogen (water gas) with the aid of nickel. This same metal, on the other hand, also assists the dehydrogenation or reduction and degradation of hydrocarbons. In the reduction of aromatic nitrocompounds by hydrogen copper renders useful service; the catalyst of the reduction of indigo white is again nickel, acids and alkalis helping as promoters. In the important electrolytic reductions hydrogen is liberated at the kathode, and the metallic kathode itself acts as catalyst; in electrolytic anodic oxidations, *e.g.*, of anthracene to anthraquinone, the catalyst is ceric sulphate. The preparation of acetaldehyde and acetic acid from acetylene is a hydration process depending upon the catalytic efficiency of mercury salts. That the vulcanisation of rubber by sulphur is catalytically promoted by litharge and lime and by various organic accelerators has long been known; the synthesis of rubber—so far as solved—is technically a polymerisation of certain unsaturated hydrocarbons, butadiene, isoprene, &c., with the aid of metallic sodium and other catalysts.

All these and many other processes are well explained by Professor Henderson, and references to the latest patent and other literature are added. Professor Henderson disappoints the reader, however, as to names. We mentioned a new German ammonia process. Five patents are quoted by numbers in this instance, but no name is given, and that is unfortunately so in many other cases. The various acetylene processes are due to a few inventors; we look in vain for their names. Reiterated statements such as "another patent," become positively annoying. Professor Henderson no doubt has the information in his notes; why does he withhold it in a book on industrial chemistry? We had to comment upon this point in reviewing another volume of the same series, "Monographs on Industrial Chemistry," edited by Sir Edward Thorpe.

* We noticed the Bergius processes in our issues of August 22, 1913, page 262, and October 24, 1913, page 564.

BELGIAN INDUSTRIAL FAIR, 1920.—The city authorities of Brussels have decided to hold the National Industrial Fair in April, 1920, instead of next September, as originally intended. Reconstruction is proceeding rapidly in all industries.

SOME DEVELOPMENTS IN AIRCRAFT DESIGN AND APPLICATION DURING THE WAR.*

By the Right Hon. Lord WEIR OF EASTWOOD, P.C., Honorary Fellow.

(*Continued from page* 61.)

Wing Structure.—General development in wing construction of aeroplanes, during the war, has been more in the nature of refinement of detail, than of evolution of methods.

With increased knowledge concerning the loads to which the structure is subjected during flight, has come the possibility of more scientific proportioning of the structural members; but beyond this the general arrangement of the wing has remained unchanged. The structure percentage weight has shown the effect of increased knowledge, and this percentage has now reached a very low value.

The effect of attention to detail has also been to give a general cleaning up and simplicity to the appearance.

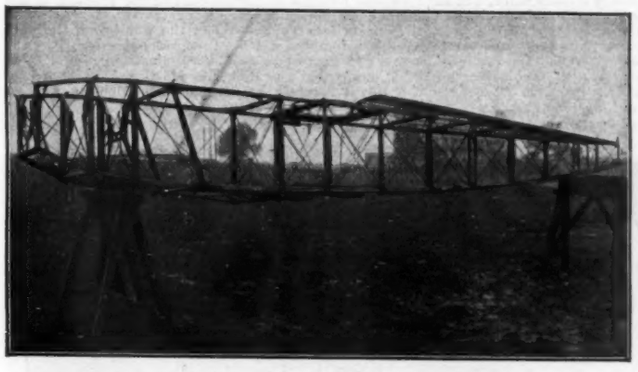


FIG. 8. BRACED N. GIRDER FUSELAGE. FAIREY.

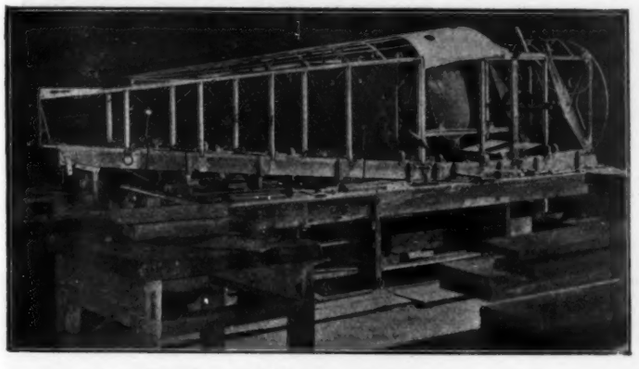


FIG. 8A. BRACED N. GIRDER FUSELAGE. CAMEL.

In external bracing, changes have taken place in some particulars. In 1914 the duplication of the main lift wires was considered to be very important, if not essential; now, in the event of one wire getting shot away, the loads are taken through the incidence wire which are those seen when looking at a wing from the side. At the commencement of the war, hard drawn piano wire was used for the main lift and anti-flying wires in many types; when this was not used, stranded cable was employed. The use of these materials has been superseded by stream-line wires. These consist of high-tensile steel rods of a lenticular section rolled from bar. The ends are left circular, and threaded to form a simple means of attachment to the fittings. These wires have proved very satisfactory, and initial troubles, due to crystallisation of the metal through vibration, having been overcome, this is now the commonest form of bracing. Hard drawn piano wire has disappeared, but cable is still extensively used, particularly in types where high performance is not essential.

The design of interplane struts has undergone certain changes. The cylinder aeroplanes had struts of stream-line section made from solid spruce, and occasionally steel tubes faired off to a stream-line form by light fairings were used. With the growth in size of aeroplanes and the increasing scarcity of suitable wood, built up or laminated struts were used. Also, with the standardisation of steel tubes for aeroplane work, and an enormously increased production of these, this form of strut became very popular. It is a most efficient construction, particularly for the landing chassis.

Internal bracing wires have gone through much the same process as the main plane bracing wires—at the commencement of the war, piano wires were invariably used, but these have now almost universally been superseded by swaged rods, screwed at the ends for fitting purposes.

During the war also, the scarcity of silver spruce occasioned the development of new methods of spar construction. These were originally always in one length from the centre section to the wing tip and spindled from a solid section. The first effect of timber shortage was to introduce a system of splicing, and much experimental work was carried out to determine the best form of splice to be used. The result of this work was that a straight scarf joint sloped 1 in 9 was adopted as a standard. This scarf was glued, pegged and wrapped with fabric. Its efficiency was high when compared with the solid spar, and it was a simple job when considered from a production point of view.

The splicing of spars was not found sufficient to overcome the timber shortage, and the need became evident for some change in design by which small scantling timber could be used, even for the spars of large aeroplanes. Further experimental work was put in hand, this time to determine the effect of laminating spars, *i.e.*, glueing thin strips together, and from this built-up section constructing spars in the ordinary way. At the same time experiments were made on box spars, *i.e.* the spars, instead of being made of the common "I" section were made in box form, the flanges and webs being formed of separate pieces of materials, glued and bradded together. Both the laminated and box spars were found to be very successful, and both types were immediately put into service. No trouble has been met with from their use. Indeed, it is probable that better quality spars are obtained from this means than by cutting from the solid at any rate for large aeroplanes. The smaller the scantlings, the easier inspection becomes, and the more guarantee is there that first-class material only is being used.

Splicing and the building-up of spars have proved such successful innovations, that there is no doubt that these methods of spar construction, introduced purely as war measures to overcome the serious timber shortage, will remain as standard in the future.

Fuselage Construction.—Fuselage construction has undergone very few changes, during the period of the war, as regards methods. Larger aeroplanes have been built, and this has naturally meant greater attention to the construction, but the bread lines of design have remained fairly well the same.

There are three principal types of construction adopted in present-day practice.

1. The braced N girder fuselage (Figs. 8 and 8A).
2. The three-ply covered fuselage (Fig. 9).
3. The monocoque fuselage (Fig. 10).

The first of these consists of four longerons, or fore and aft rails, braced by a system of struts and diagonal wires in all four faces. Fabric covering completes the structure. This is the commonest type of design.

The second system retains the longerons and the vertical and horizontal struts, but in place of bracing wires and fabric, thin three-ply is glued and bradded to the framework.

The monocoque fuselage dispenses with the longerons and consists of a single sheet of three-ply or veneer moulded to shape on formers.

As a general rule, three-ply frames are provided as bulkhead bracing at intervals along the length. There are several varieties of this construction, but the essence of them all is the tubular construction of thin veneer, the formers or bulkheads merely being inserted to stabilise this skin.

FIG. 9. THREE-PLY COVERED FUSELAGE. DE HAVILLAND 10.

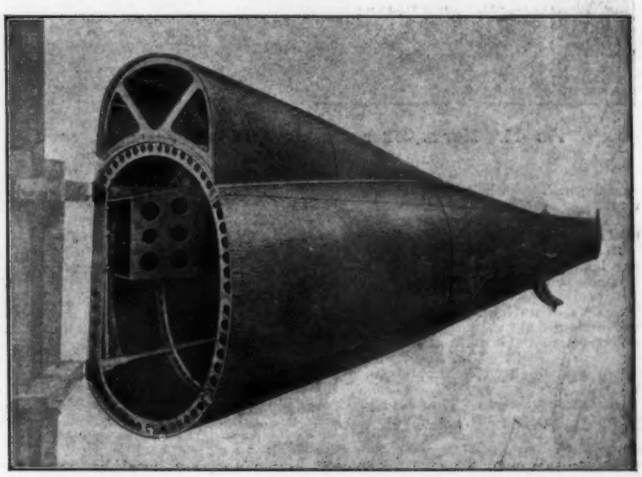


FIG. 10. TYPICAL MONOCOQUE FUSELAGE (PARNALL PANTHER).

Of the three methods of construction, the first and third were known and adopted before the war, and modifications have been more in the nature of improvements in manufacture than in fundamental alterations in principle. The second method was, I believe, first used by the Germans in their early Albatross scout at the beginning of the war, but has since been used with great success by British designers, notably in the case of the De Havilland designs.

Monocoque Construction.—The monocoque method of construction was adopted by the Germans at an early date and was later almost universally used by them. The probable reason for this was their ample supply of high-grade three-ply, rather than any constructional or aerodynamical advantages which they attached to this method of construction.

The chief advantage from the service point of view, of a monocoque method of building fuselages lies in its invulnerablity to casual bullets. In an ordinary fuselage a bullet striking a main longeron or strut might quite

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders, July 10, 1919.

possibly cause the structure to collapse, whereas a monocoque will stand up to any number of bullets. A disadvantage is that truing up becomes difficult, and special arrangements are necessary to overcome this defect.

Our supplies of three-ply were deficient almost up to the end of the war, owing to the failure of the Russian supplies, and this no doubt had a considerable influence on our designers and manufacturers. One of our firms did develop a very simple method of constructing in three-ply, which would have admitted of a large production, but the particular aeroplane was not adopted for other reasons.

It was thought at one time that the rounded fish-like form of monocoque would considerably lessen air resistance, and would enable a higher speed to be developed. The importance of this, however, has been a good deal exaggerated; the advantage gained is not worth very much.

The monocoque construction offers great opportunities of development for commercial aeroplanes, as it leaves the space inside the skin free from obstruction, a very considerable advantage when carrying mails, goods or passengers, and in this respect it has a great pull over the standard braced fuselage where diagonal bulkhead bracing wires occur at every panel. It has also a considerable advantage in the almost complete absence of metal fittings, making for ease of construction.

The largest aeroplane yet built—the Tarrant Tabor—has a fuselage 11 ft. in diameter, which has been built on a modification of this principle, the skin being made of layers of thin laths glued and tacked over formers until set. The skin is stabilised by latticed hoops of wood, and the resulting structure is a very light and strong weight and in reliability will be more marked in the case of large types than in small ones. The uniformity of strength obtainable in metal will give it a marked advantage over wood, and will enable aeroplanes to be made without such large allowances for variations of material.

The Germans, on the other hand, were driven to the necessity of employing metal at an earlier date than ourselves, and although they never turned out any metal structure which would have satisfied us, this form of construction was very considerably employed. Their A.E.G. twin engine bomber was almost entirely made of metal, but it was relatively heavy and allowed only a very small weight of bombs or fuel, before it became dangerously overloaded. For the spars they used high-tensile steel tubes which are not altogether satisfactory for use as a combined strut and beam.

At the end of the war there certainly did appear an all-metal German aeroplane which was called the Junker monoplane. This was of a quite novel type of construction, the wings being covered with corrugated aluminium sheeting and having multitudinous internal tubular bracing. A very thick wing section was employed. The performance was not good and it is doubtful if the type would have really been of any serious value, but as a piece of construction it showed considerable merit.

The Progress of Design and Construction of Propellers.—The screw propeller has for many years been used as an organ of propulsion for marine craft. It was not, therefore, a totally new problem with the advent of aircrait. In its use on aircraft the propeller altered its shape, and the blades became longer and narrower as compared with marine practice.

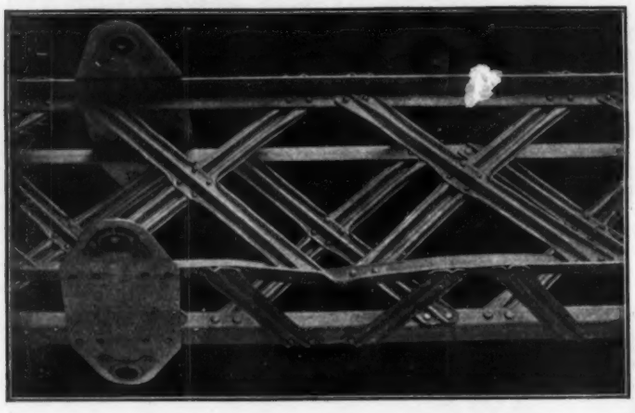


FIG. 11. METAL CONSTRUCTION. VICKERS DURALUMIN.

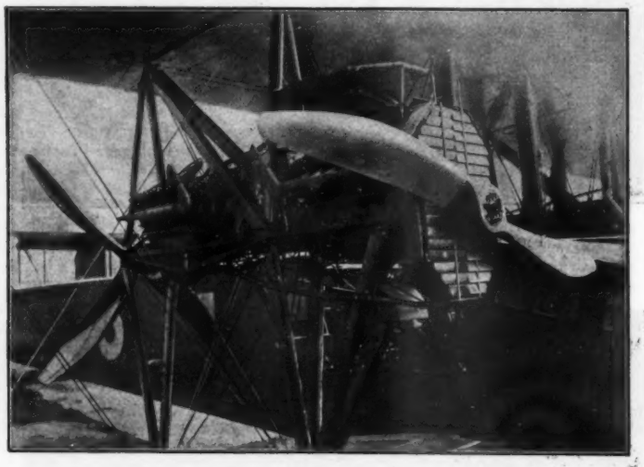


FIG. 12. TANDEM PROPELLERS. HANDLEY PAGE V. 1500.

uselage with the whole of its interior free from obstruction.

The regrettable accident to this machine on its first trial in no way reflects on the basis design of the machine.

In a flying boat, the hull has to function both as a boat, as a landing carriage, and as a fuselage, and it is not uncommon to hear of the seaplane, as a class, being under serious disadvantage to the aeroplane because of the heaviness of its hull. Our experience during the war has brought us to the point of being able to state that a well-designed hull is no heavier than a fuselage and landing carriage, and that sea aircraft are therefore under no disadvantage under this heading as compared with land aircraft.

Metal Construction.—There is no doubt that the future of metal construction for aircraft is very promising. The amount of work and time entailed in designing metal structures is very much greater than that required for wooden ones, owing to the experimental work involved. There is also the difficulty of introducing modifications during the production stage, modifications which were continuous, during the war, owing to service demands to meet new and unexpected conditions. During the war, therefore, metal construction has not been generally adopted. Its future, however, was clearly seen, and a great deal of experimental work was done, principally in connection with the Avro Training aeroplane. At the end of 1917, as I have said before, there was a shortage of good quality timber, and a still greater shortage was foreseen as probable in the future, owing to the demands of the enlarged programme. A big effort was made to employ metal for the Avro which was absorbing something like one-third of our total wood supplies, and which was a thoroughly well-established type, with an assured future for training purposes.

The experimental work done in this direction was very considerable, and much interest was aroused among manufacturers. As a result, it can be definitely stated that, even for such a small type, the use of metal enables the wings to be made slightly lighter and distinctly stronger than is possible with the best quality spruce. The experimental work necessary to get at this result was so extensive and protracted that the type was not actually produced in metal in quantities, but the information obtained was of the utmost value and was well worth the effort.

Experimental work was also carried out in the application of metal construction to larger aeroplanes, and there is no doubt that the constructional gain both in

At the outset trial and error methods were applied, and a suitable propeller was arrived at only after the trial of a large number of designs. The variations met with in aircraft work are very great. At the present day, aircraft speeds vary from 40 m.p.h. in the airship to 150 m.p.h. in the aeroplane. The engines vary from 40 h.p. to 600 h.p., while the propeller revolutions vary from 500 per minute to 2,200 per minute. With such wide variations in conditions a surer and quicker method of arriving at the best results was demanded. Curiously enough, aircraft propeller designers had recourse to a method devised by M. Drezweichi in 1882 for the design of marine propellers, which consisted of a mathematical analysis treating the propeller blade as a rotating wing. The method was tested at the National Physical Laboratory, and is now in general use, with the result that it is rarely necessary to test more than two propellers to arrive at the desired result. Frequently the result is obtained with sufficient accuracy in the first trial design.

The efficiencies now obtained in aircraft propellers are high, being 75 per cent. as an average, and frequently 85 per cent. under optimum conditions.

As regards construction, the peculiar vibration and variation of torque prevented the use of metal, which quickly fatigued and failed. For this reason and also for quickness in manufacture, wood became and still is the principal material used.

Only the highest class material was suitable, for, at the speed at which modern aircraft engines run, the radial pull at the root of a propeller blade may be as much as 5 tons, while at the same time the propeller has to pull the aircraft along, involving bending moment due to forces of as much as ½ ton per blade. The stresses due to these combined forces were satisfactorily met with for the smaller powers, but at one time it was thought that the size of engines would be limited by the maximum power which could be transmitted through a single propeller. And such might have been the case, had it not been discovered that instead of the stresses due to these two forces adding to each other, it might be arranged so that the bending stresses due to centrifugal action would completely neutralise those due to the thrust.

The only limits now imposed on propeller design are :—

1. Tip speed.
2. Constructional limitations.

As regards the first, experiments have shown that a tip speed equal to the speed of sound should not be exceeded, and to this speed we are rapidly approaching. In the standard propeller for the American Liberty engine in the D.H. 9A, the tip speed is 880 ft. per second as compared with 1,050 ft. per second for sound. This difficulty, however, is met by gearing the engine so as to reduce the propeller speed. Provided the engine is suitably geared so that the tip speed does not exceed 900 ft. per second, there appears to be practically no limit to the amount of power which can be transmitted through a single propeller. Even with present-day methods of construction it is safe to say that 2,000 h.p. can be transmitted through a propeller mounted on an aircraft flying at 80 m.p.h. and as much as 6,000 h.p. on an aircraft flying at 150 m.p.h.

As regards the question of commercial construction, development has been along normal lines; improvements have been made in the details of manufacture such as the glueing of the numerous wood laminations, and the protection of the blade with fabric and metal edgings; and the general result has been a better and more reliable article. Nevertheless, the use of wood is not wholly satisfactory, especially for future commercial work, involving flight through tropical countries, and we therefore look forward to the solution of the problem of the metal construction of propellers.

Division into Types.—When the war began the only aeroplane function which was considered seriously by the army authorities was that of reconnaissance, and there is no doubt that the B.E. 2A, which was developed by the Royal Aircraft Factory for this function was an excellent aeroplane, thoroughly well adapted for its work.

Reconnaissance Aeroplanes.—These early aeroplanes were not intended to carry any military load other than crew, but almost from the very start of the war the military load required began to increase, with the result that all through 1915 and well into 1916 our reconnaissance aeroplanes were overloaded with all kinds of equipment, such as guns, gun mountings, cameras, wireless apparatus, &c., which were attached to any available part internally or externally. In order to carry out their requisite functions, this additional equipment was necessary, but it naturally meant a very considerable reduction in performance. The speed was brought down 10 miles or 15 miles an hour, while the extra weight and resistance had a very serious effect on the rate of climb. This is shown by the diagrams giving the performances at the different periods of the war; it is not until the latter part of 1916 that any appreciable improvement in performance can be seen, and then both the speed and the climb go up rapidly.

It was at this period that the special military aeroplanes, designed subsequently to August, 1914, first came into use, and in these full allowance was made for all equipment to be carried. The increase in performance was due not only to the higher power engines used, but also to the fact that the aeroplanes were designed to carry the equipment as far as possible internally, thus avoiding all unnecessary resistance.

As aerial tactics developed, the roles of the pilot and observer altered, and the latter practically confined himself to being a pair of eyes in the back of the pilot's head, whereas the pilot had to do all the reconnaissance artillery, spotting, &c., as well as fly the aeroplane.

Single-Seater Fighter Development.—As well as doing one's own scouting, it was necessary to stop the other side doing his or rather to stop him from taking his reports home. This meant fighting, and fighting meant guns and better performance. The early aeroplanes were soon fitted up with a Lewis gun fixed so as to fire over or at the side of the propeller disc, and actuated by a Bowden wire. This gun was at first fixed to fire upwards at a considerable angle to the line of flight, necessitating an oblique method of attack. Then later, in order to enable the aeroplane itself to be aimed directly at the objective, the gun was mounted on stands and in a line practically parallel to the propeller shaft. It was found

that, by aiming the aeroplane itself rather than an independent gun, shooting was more accurate. The attachment of all this gear and weight to machines which were not designed for them was a very serious handicap, and performances were reduced 15 per cent. or 20 per cent. on speed and ceiling.

Late in 1915 the Germans brought out a system of synchronising the trigger with the engine, so that the bullets went between the blades of the propeller. This scrap of unnecessary weight eliminated by careful design. The view, particularly overhead, was not very good, but the aeroplane was so handy fore and aft that this did not interfere very seriously with its fighting qualities. This type lasted a very considerable time before it was superseded, which, in view of the comparatively small horse-power, was remarkable. During the period in which this type was in use fighting acrobatics advanced to a marked degree, and in the next type an effort was made to increase view and manœuvrability. This was the Sopwith triplane with another French engine of 110 h.p. to 130 h.p., and its characteristics can be clearly seen in Fig. 21.

In the next type, which was in design at the end of 1916, and came into production in 1917, we see the influence of these considerations upon the mind of the designer, who by the way was Mr. Hawker, of Trans-atlantic fame. We have here a very simple and, though unstable, an easily controllable biplane with two guns. Enormous numbers of this type were produced in the course of the next year or two with French and English engines which increased in power up to 150 h.p. The type was nicknamed the "Camel" because of the curious hump in the fuselage.

The next type on our list is the S.E. 5 designed at the Royal Aircraft Establishment, Farnborough. This is really a direct descendant of the B.E. 2A with which we started. It was a very long time coming into general use, principally owing to delays with the engine, a

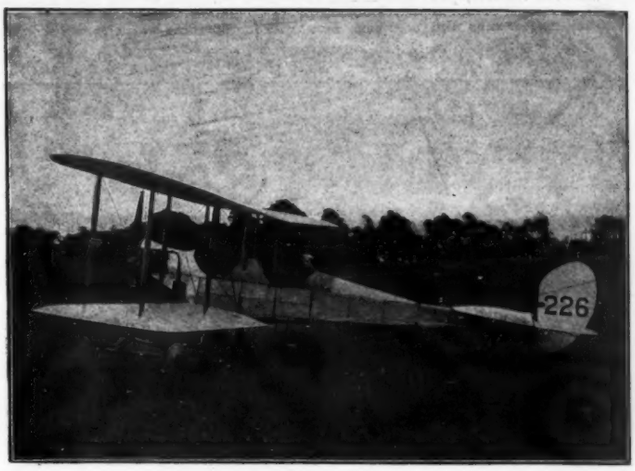


FIG. 13. B.E. 2A.

FIG. 16. ARTILLERY MACHINE. ARMSTRONG-WHITWORTH F.K. 8.

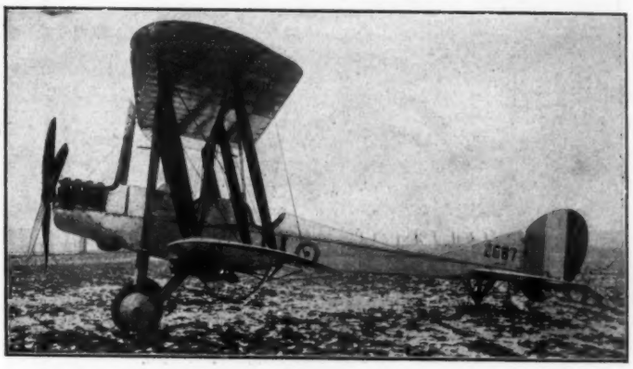


FIG. 14. RECONNAISSANCE MACHINE. B.E. 2C.

FIG. 17. ARTILLERY MACHINE. DE HAVILLAND 4; EAGLE VII.

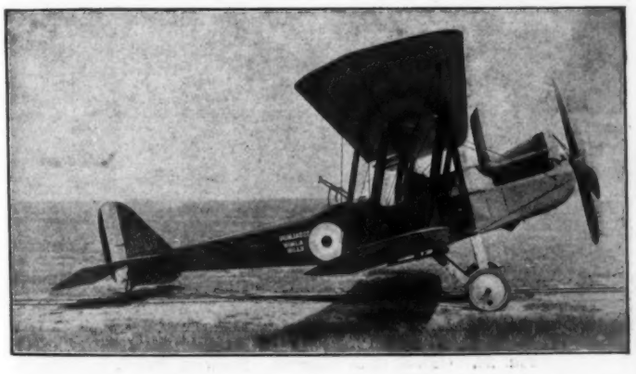


FIG. 15. RECONNAISSANCE MACHINE. R.E. 8.

FIG. 18. ONE-SEATER FIGHTER. BRISTOL SCOUT.

was a great improvement as it enabled the gun or guns to be fixed alongside the engine, within easy reach of the pilot, and offering very much less wind resistance. The Vickers gun was quickly adapted to work in a similar manner on our tractors, and by the late summer of 1916 our single-seater fighters were on a par with the Germans'. During this period, in addition to the tractors with exposed Lewis guns, we had been making very considerable use of small single-seated pushers of remarkably good performance considering the difficulties of the proposition.

The characteristics of the Sopwith Pup, our first good tractor single-seater, were very light surface loading, a small but good rotary 80 h.p. French engine, and every

The loading per square foot had increased, but the loading per horse-power had decreased considerably, and the performance was better. Some of the aerodynamic disabilities of the triplane were overcome by the pronounced forward stagger and the use of a single strut. This single strut system increased the difficulties of manufacture and repair, particularly as regards truing up. Both this aeroplane and the one before it were provided with only one synchronising gun, and the rate of fire was consequently slow.

In aerial fighting, the time in which it is possible to hold the enemy on the sights is very short, and one gun was found insufficient, apart from the considerable chance that the one guns might jam at the crucial moment.

200-h.p. water-cooled French Hispano. Opinion was by no means unanimous as to the fighting value of this aeroplane compared with the "Camel," and each type had its school of adherents. The S.E. 5 had a better performance, particularly at a height, was stable and manœuvrable, very easy to fly, and had better visibility due to the pilot being farther back. On the other hand, it was much more difficult to produce and the engine and its accessories gave a great deal of trouble both at home and in the field. By this time we had reached a point where the performance of our aeroplanes was very considerably in advance of that of the Germans, who were cramped by their non-elastic engine policy.

The next type to come into general service was the

Sopwith "Snipe." The engine here was a 200-h.p. B.R. 2 of British design. It would appear that this size of air-cooled rotary engine has reached, if it has not in fact surpassed, the maximum size for efficiency. The performance was rather disappointing and must be attributed to the enormous engine diameter and air resistance. Several competitive aeroplanes from different makers were tested simultaneously with this one, and the results were practically all the same. You will notice that the control surfaces are balanced. In this way the necessary manœuvrability was maintained, although the weight of the aeroplane had reached rather a high figure. The actual selection of this type was largely governed by the engine position which entailed the placing of orders on a production scale before trials of the actual engine and aeroplane were carried out.

Finally we come to the Martinsyde F. 4 which, although in production, was never used at the front previous to the signing of the armistice. This had another water-cooled engine—275-h.p. Rolls-Royce of high efficiency. Both aeroplane and engine were very good, and although the former was heavy and somewhat large, it was wonderfully manœuvrable. The performance reached was very high—over 130 miles an hour at 15,000 ft. with a climb to that height in 12 minutes.

The increase in speed and climb from period to period is shown on Fig. 54.

Two-Seated Fighters.—Apart from the particularly interesting case of the single-seaters, there developed from the use of the original reconnaissance type, a demand for, and a supply of two-seated fighting aeroplanes, which could do their reconnaissance work and defend themselves, if attacked. As the best method of defence has always been, and will be, to attack, these machines which were in principle defensive, became very effective in the offensive. Our two-seated pusher fighters, such as the Vickers or the F.E. 2s, gave a very good account of themselves, until the time came when their poor performance, as compared with the tractors, put them out of date.

The first really good two-seated tractor was the 1½ Strutter, so called by the Sopwith Company because of its peculiar wing strut system. This aeroplane was, and still is, one of the most efficient ever designed, and for its engine power (130-h.p. Clerget) it has never been surpassed. In it the pilot was placed as close up against the engine as possible with a very fine view ahead and downwards. The gunner was now put behind him with a rotatable Lewis gun turret. He had a very good view downwards and all round the rear. This arrangement, which is, in principle, still standard, gave a very manœuvrable aeroplane owing to the concentration of the weights; and on account of its high performance the type became a very effective offensive weapon.

Early in 1917 there appeared another two-seated fighter where the qualities enumerated above were still further developed. This was Captain Barnwell's Bristol Fighter with a Rolls-Royce Falcon engine. Both aeroplane and engine were exceedingly good. The view from the pilot was improved by putting him farther back and higher so that he could see over the top plane, and being closer to his gunner, they could communicate better. Close communication in this sort of fighter is a very vital matter, and probably this type did more to establish our superiority over the enemy than any other.

Bombers.—Reverting to our original B.E. 2As., from which we have seen the development into one-seated fighters and two-seated bombers, we can trace also the development of the bomber. This was the type of aeroplane first used for bombing purposes, as soon as bombing, as a useful and military function, was appreciated. There were sporadic efforts at bomb dropping by 80 Gnome Avros, but when it developed into organised attacks with numbers of aeroplanes, the original reconnaissance type was used. As soon as the real requirements of this work were understood specially-designed aeroplanes appeared. In the early types the bombs were fitted in all kinds of ingenious but crude ways, with pieces of string and cutting knives, &c., and the attacks were made by diving to a low height and planting the bombs by the pilot's judgment. Although great efforts were made in the training of bomb droppers and in the perfection of sighting and releasing apparatus, &c., accuracy from a height was never really obtained, and experiments conducted towards the end of last year, proved conclusively that the only way to hit any isolated object with certainty was to dive to a low height before

FIG. 19. ONE-SEATER FIGHTER. DE HAVILLAND 2.

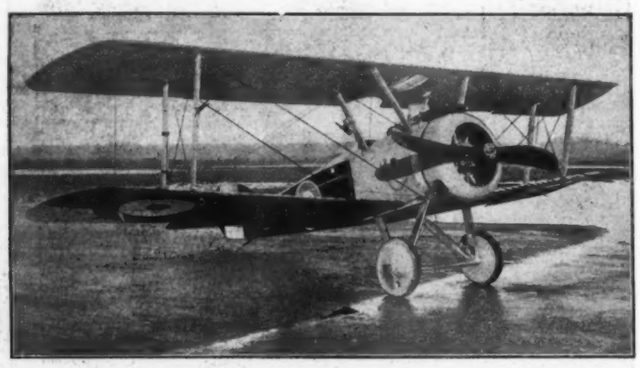


FIG. 22. ONE-SEATER FIGHTER. SOPWITH CAMEL.

FIG. 20. ONE-SEATER FIGHTER. SOPWITH PUP.

FIG. 23. ONE-SEATER FIGHTER. S.E. 5.

FIG. 21. ONE-SEATER FIGHTER. SOPWITH TRIPLANE.

FIG. 24. ONE-SEATER FIGHTER. SOPWITH SNIPE.

SOME DEVELOPMENTS IN AEROPLANE DESIGN.

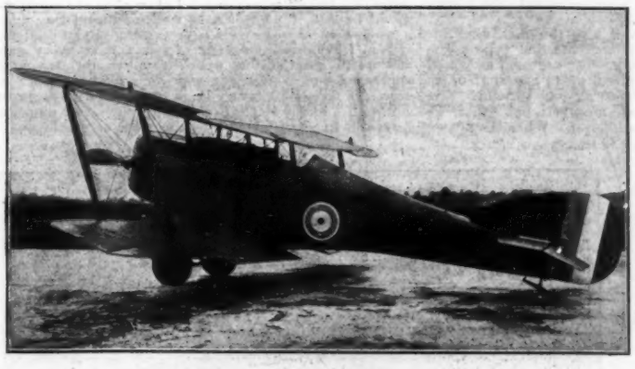


FIG. 25. ONE-SEATER FIGHTER. MARTINSYDE F 3.

FIG. 26. TWO-SEATER FIGHTER. VICKERS GUN BUS.

FIG. 27. TWO-SEATER FIGHTER. F.E. 2 B.

FIG. 28. TWO-SEATER FIGHTER. SOPWITH 1½ STRUTTER.

FIG. 29. TWO-SEATER FIGHTER. BRISTOL-ROLLS-ROYCE.

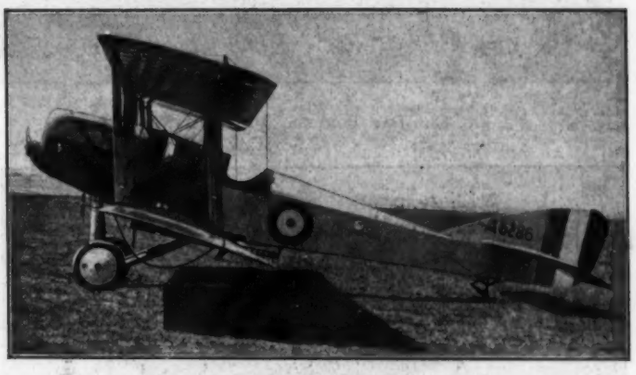


FIG. 30. DAY BOMBER. MARTINSYDE 160 H.P.

FIG. 31. DAY BOMBER. DE HAVILLAND 9.

FIG. 32. DAY BOMBER. DE HAVILLAND 9A.

letting go the bombs. Nevertheless the moral effect of bombing is immense in disturbing industrial work and the manufacture of munitions.

With the introduction of the B.E. 2c, systematic bombing of the enemy's positions was carried out, but this aeroplane was capable of making comparatively short raids only, and when loaded with bombs could not carry an observer. With its moderate speed it was rather an easy prey for enemy scouts under such circumstances.

The Martinsyde single-seater bomber with the 120 and later the 160 Beardmore engine was a distinct high speed, and were very fast in the air. On returning home, after the fuel was consumed and the bombs dropped, they could land easily enough, but if by chance they had to land with full load on board, the pilot's difficulties were considerable.

Just as the original B.E. 2 was the first used for bombing by day, similarly it was the first type to be largely employed for bombing by night, for which function it was very fairly suited, up to the limit of its capacity, as it was very easy to fly and to land. The weight-carrying capacity was, however, not great, as the engine was only 70 h.p. to 100 h.p. When the bigger attempt to make a very long range bomber, to attack Berlin itself, from a base in England. The actual point-to-point distance is about 450 miles, and a minimum range of 1,100 miles was decided upon. As the aeroplane would have to fly by day, as well as during the night, it was essential to provide a very complete gun defence system. This meant a crew of seven, with many guns and much ammunition, apart from wireless telegraph apparatus and bombs. It was clear that it would be necessary to employ a very large aeroplane with powerful motors. The 350 Eagle Rolls being the biggest and best geared engine available, it was decided to employ four,

FIG. 33. DAY BOMBER. DE HAVILLAND 10A.

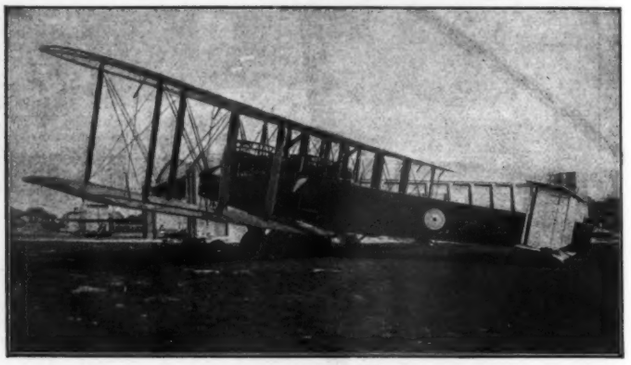


FIG. 36. NIGHT BOMBER. HANDLEY PAGE V/1500.

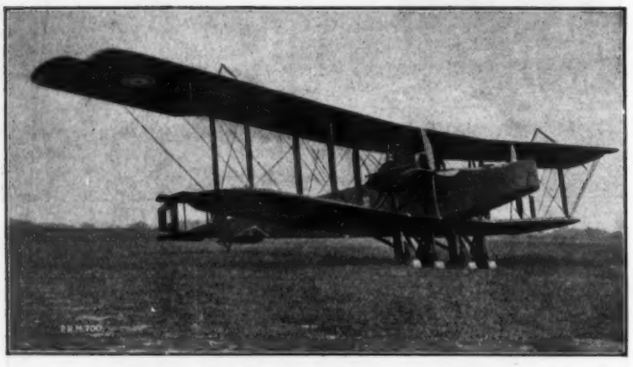


FIG. 34. NIGHT BOMBER. HANDLEY PAGE O/400.

FIG. 37. GROUND FIGHTER. SOPWITH SALAMANDER.

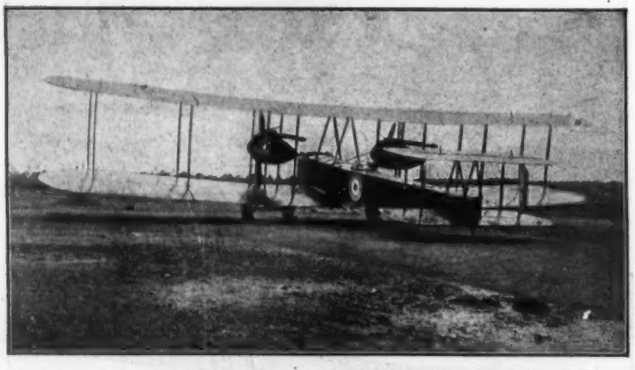


FIG. 35. NIGHT BOMBER. VICKERS VIMY.

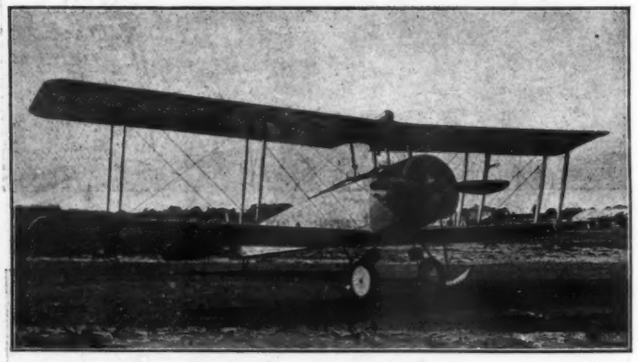


FIG. 38. TRAINING MACHINE. AVRO.

advance as regards range, while its greater speed made it a much better fighter.

As bombing developed, a subdivision of type into definite branches took place. These were day bombers, short distance and long distance; and night bombers, short and long distance. From an aerodynamic point of view the design of a high-speed, long range weight-carrying aeroplane is an exceedingly difficult problem, but it can be fairly stated that our designers, particularly Captain De Havilland of the Aircraft Manufacturing Company, found the solution in advance of those of other countries. His aeroplanes eventually had wing surfaces of high efficiency and of high superficial loading, combined with structures of great cleanliness and low air resistance, and with the most powerful engines available at the time. Owing to their low weight per horse-power his machines could get off easily though at a

engines became available this bombing work was taken over by the F.E. 2 pushers, which were good weight carriers and had a better view for bomb sighting.

The above remarks apply more to the military flying corps than to the naval service, which made use of any aeroplanes they could get hold of, particularly French ones, such as Caudrons and Farmans. Later, they used the Sopwith 1½ strutters, and finally Handley-Pages. This latter type was the first really effective design of night bomber, and came into use early in 1917. Its general features are so well known that it is unnecessary for me to enlarge upon them. When, in the autumn of 1917, a big programme of bombers was laid down, this was the type decided upon. The Vickers-Vimy was a later machine of the same general type embodying more recent experience.

At the end of 1917 it was considered to be worth an using a system of tandem propellers, which theoretical investigation showed to be reasonably efficient. The main lines of the design were quickly arrived at, and arrangements made for the building of a few experimental aeroplanes, by a large firm of shipbuilders in Ireland. In order to get a straight run on the design and to avoid interruption, Mr. Handley-Page, the designer, went over to Ireland with a large proportion of his design staff, and after six months very hard work, the first of the batch came over to Cricklewood, to be erected and tested. Many difficulties, particularly connected with the control, were encountered and surmounted, and on November 8, three days before the armistice was signed, two of these aeroplanes were standing ready and fully equipped to start for Berlin.

GROUND FIGHTERS.

Armoured Aeroplanes.—In the very early days of the

war the aeroplane had little to fear from enemy action provided it crossed the lines at any height above about 3,000 ft., so as to be out of range of ordinary rifle fire from the ground. The introduction of the special anti-aircraft gun, however, very quickly altered this state of affairs, and the aeroplane was driven higher as the accuracy of fire improved; until, at the end of the war, there was no immunity from danger from anti-aircraft fire at a height of 20,000 ft.

For a long time it was considered that the risk of a low-flying aeroplane being hit by rifle or machine-gun fire from the ground was so great that we should not be justified in using our pilots and aeroplanes in this way. The remarkable escapes experienced from time to time by pilots forced to return across the lines at very low altitudes, however, encouraged the idea that the risks of low flying had been a good deal exaggerated, and a most effective mode of attacking the enemy was gradually developed. The first important success in this direction was, I believe, achieved by Lieutenant-Colonel Bishop V.C., who attacked an enemy aerodrome soon after daybreak. After riddling the officers' and men's quarters with bullets from his machine guns he turned his attention to the German aeroplanes which had been brought out to attack him. He put two or three out of action on the ground, brought down three in succession as they got into the air, and then returned safely to his own aerodrome. Thereafter this method of attack developed very rapidly, and it proved of the greatest value later on, not only in breaking up the dense infantry formations advancing to attack us after March 21, 1918, but in demoralising the retreating enemy when we subsequently advanced. A system of co-operation between our low-flying aeroplanes and the infantry was also evolved, and this proved of the greatest value in keeping the infantry and the headquarters behind in touch with what was going on in front. The aeroplanes used were the single-seater fighter—especially the light, manœuvrable "Camel"—for attacking ground targets from very low altitudes; and the standard artillery machine for the infantry co-operation from rather greater altitudes.

Our casualties in these operations were naturally heavy, and the problem of providing a suitable armoured aeroplane arose. As a result the Sopwith "Salamander" was designed, and was just about to make its appearance in the field at the time of the armistice. This was a single-seater fighter with B.R. 2 engine, equipped with two Vickers' guns and a very large amount of ammunition for attacking ground targets, while it carried nearly 650 lb. of armour plates, so arranged as to give the pilot and all vital parts of the aeroplane adequate protection from German armour-piercing bullets fired from the shortest ranges. In spite of this heavy load it had a speed of 125 m.p.h., and was sufficiently manœuvrable for the pilot to make the attack by diving at the target, thus getting the advantage of firing in the direction of flight. Had the war lasted a few months longer this aeroplane would probably have done most effective work in hastening the German retreat.

An armoured two-seater for infantry co-operation was also designed and produced, but like the "Salamander" it was too late to come into actual service.

(To be continued.)

SWEDEN AND THE LYONS FAIR.—According to *Swedish Export*, Sweden has been officially invited to take part in the Lyons Fair next October, and the Foreign Minister has requested the General Export Association to take suitable measures to ascertain the views of Swedish exporters concerning participation in the Fair.

DEPARTURE OF ALIENS FROM THE UNITED STATES.—We read in *The Marine Journal*, New York, that June 24 was a record day for the departure of aliens from that port since 1914. The Dante Alighieri carried 1,800; the Duca degli Rbruzzi and the Madonna, 1,400, for Italy; the Royal George carried a full complement for England, and the Za Cappa a goodly number for South American ports. Some idea of how departures are increasing may be gathered from the fact that during December last 10,000 aliens left, a daily average of 384, whereas in May, 23,812 left, a daily average of 993. For June, the daily average will be considerably over 1,000.

OIL AND PRODUCER GAS FOR HEAT-TREATMENT.—A comparative test of oil and producer gas for heat-treatment purposes was recently conducted by the Ford Motor Company, Detroit, says *The Iron Age*. The test was made on a furnace of the common underfired type. The oil used had a heat value of 18,000 British thermal units per pound, or 140,045 per gallon. The material under heat treatment was steel gear blanks in a flat ring, having an average weight of 8 lb., the thickest part being 1 in. and the ring opening more than 4 in. Two tests were made, one with 1,048 lb. of metal and the other with 1,360 lb. It was found that there was considerable economy with the larger batch. The metal was placed in the furnace at 60 deg. F. and brought to 1,560 deg. F. in 35 minutes. The heat was held until the total elapsed time for the charge was 1¼ hours, and the metal was then raked out. The saturation period was thus a little less than 1 hour. The average time to bring the charge to heat with oil was 39 minutes, and a trifle over 35 minutes with gas. The second run with a larger batch requried 38½ minutes. The heat required per pound of metal with gas was found to be 788 British thermal units, with oil 1,247 British thermal units. This gave an efficiency with oil of 14·1 per cent. and with gas 22·3 per cent. For saturation the heat required per pound of metal with gas was 533 British thermal units, and with oil 948 British thermal units. On the second run, with 1,360 lb. of stock, a heating efficiency with gas of 26 per cent. was obtained.

CATALOGUES.

Concrete Mixer.—The mixer made by Winget, Limited, 25, Victoria-street, S.W. 1, has a stationary barrel (tiltable for emptying) and revolving chain-spades which toss up the ingredients and effect a quick and thorough mixing. It is mounted on road or rail truck wheels with engine, the transmission being by universal joint and clutch. It is used for both wet and semi-dry concrete. The new catalogue gives very full information of construction and capacity.

Die Blocks.—Those who are concerned in making and using forging and casting dies should give a careful reading to the catalogue issued by Messrs. Brown, Bayley's Steel Works, Limited, Sheffield, who make steel blocks for dies. The difficulties of making and treating the blocks, especially for various uses, are discussed very frankly and with none of that pretension to perfect knowledge that creates distrust in the practical man. Advice is given as to the choice of steel for various purposes, the face of the cube on which it is best to cut the die and heat treatment after cutting. The blocks are made to stock in six qualities of steel.

Dipper Dredger.—The dipper dredger made by Messrs. Lobnitz and Co., Limited, Renfrew, is the subject of a special catalogue issued by the firm recently. This machine is built into a hull of shallow draught and carries a digging or other bucket on a crane. It is particularly suitable for confined and awkward places and will dig out a canal to as low as 12 ft. to 15 ft. wide. In action, three "spuds" or legs are projected to grip the water bottom and secure the ship. The dipper then sweeps out to the range of the jib, digging out sand, stones, earth, &c., in long slicing cuts made in the arc of a circle and depositing the material on the land or in barges. The dipper acts also to take a grip and move the hull forward or backward with the spuds up or manœuvre it with one spud in the bottom, and it can also be used to move the barges about. One man controls all movements. It is quite a marvel of "self-determination."

AMERICAN INDUSTRIAL EXPANSION.—A compilation of the new incorporations in the United States, says *Commercial America*, records a marked expansion in authorised capitalisations in recent months. For example, the record of the eastern part of the country alone for the month of May shows nearly $750,000,000 of new capitalisation, as compared with $515,000,000 in April and $370,000,000 in March, and smaller totals for the corresponding months of a year ago. While there are certain aspects of this increased flow of capital into new businesses and industries which would seem to warrant serious consideration, yet the movement as a whole reflects a go-ahead spirit upon the part of business interests which in turn indicates a feeling of security as to the future.

TORONTO TRAM CARS.—A suggestion has been made by a member of the Municipal Board of Control, Toronto, to establish municipal works for the manufacture of tram cars, in view of the fact that the city of Toronto proposes to acquire the tram-car system which is now operated by a company whose franchise expires in 1921. The following opinion of a sub-committee of a Municipal Transport Commission has been given to the Commission: "It would not be prudent for the city to embark on the manufacture of street cars. The investment entailed would be so extensive as to burden street railway operation with large overhead charges, which would seriously affect the economical administration of the system. After the primary needs of the consolidated street railway are met, the number of new cars required annually would not be sufficient to justify the maintenance of such a factory. Indeed, in the operation of street railways on this Continent, it was found by operating companies, almost without exception, most advantageous to purchase their requirements from the comparatively few manufacturers who specialise in street-car production." The municipal officials have recommended that the city should purchase its tram cars from concerns manufacturing them, instead of constructing its own cars. British firms interested in this matter, says *The Board of Trade Journal*, should communicate with Mr. R. C. Harris, Commissioner of Works, City Hall, Toronto.

ELECTRIC TOOL-TEMPERING FURNACE.—An electric tool-tempering furnace, which uses the barium-chloride and salt principle, says *Railway Mechanical Engineer*. New York, is proving highly successful in the South Philadelphia works of the Westinghouse Electric and Manufacturing Company. The chief advantages of this type of furnace over those using gas, coke, oil or wood, are constancy and ease of control of heat, cleanliness, equal heating of each atom of the specific part of the tool to be tempered, low cost of operation and excellence of the finished work. The furnace consists of an outer shell, a cast-iron cylinder packed with firebrick, and an occasional layer of asbestos. The heat is supplied by two pairs of electrodes built in on opposite sides of the walls of the inner chamber. The electrodes operate on a 16-volt to 30-volt alternating current circuit. Carbon sticks are placed between the electrodes in the chamber to complete the circuit. The current is started on the 30-volt circuit. Salt is fed in, when it is melted it completes the circuit, and the carbon sticks are removed. A mixture of barium-chloride is then fed in, the final preparation being about 60 per cent. of barium-chloride. When the temperature of the liquid reaches 1,425 deg. F. the voltage is lowered. The current regulation at the switchboard gives a quick and easy method of control, and the liquid, kept at one temperature, heats the tool uniformly from surface to centre. The furnace throws off very little heat, a feature appreciated by the workmen.

BOILER EXPLOSION AT BIRMINGHAM.

THE Board of Trade have issued a report of a preliminary inquiry as to the explosion of a heating boiler which occurred on February 10 last at the Birmingham Coffee House Company's Café, Stephenson-street Birmingham, and by which one person, a woman, was injured.

The report states that the boiler, which was used for supplying the water at high pressure to a system of heating pipes, consisted of a rectangular coil of wrought iron, butt-welded piping, 1¼ in. in external diameter by ¾ in. bore, enclosed in a sheet steel casing, partially lined with firebrick, which formed the furnace. The flow pipe, from the top of the coil, after making a circuit of the coffee room, returned to the furnace and was there connected to the bottom of the coil, thus forming an endless system of piping which was charged with water by means of a force pump. An expansion tube was fitted to the piping, slightly above the highest part of the circuit, and a fitting tee-piece was also supplied. The several lengths of pipes were joined together by couplings screwed with right and left-hand threads. The furnace was rectangular, measuring 1 ft. 9 in. in length by 1 ft. 6 in. in breadth, and 1 ft. 10 in. in height. Coke was used for fuel. A cast-iron top was attached to the casing of the stove, in which there was a firing hole covered by a door.

No repairs had, it was stated, been done to the boiler. It was supplied and fitted in its place in 1904, but the name of the maker could not be ascertained. It had been under constant observation by the manager, who had had charge of the apparatus since it was new, adding water at the filling pipe, from time to time as required. The heating apparatus was not insured.

The explosion was of a violent character. The top coil of the boiler split longitudinally along the butt-weld for a length of 3 ft. 6 in., the maximum opening being about 3 in., and was ruptured opposite the weld in three places. The casing was wrecked, three large windows in the coffee room were smashed, and some crockery broken.

The explosion was caused by the fire having been lighted in the boiler whilst a portion of the pipe circuit was blocked by ice. The circulation of the water was thereby prevented and the pressure increased under the influence of the fire until the pipe could no longer withstand it.

In his report, Mr. Tremain, Surveyor to the Board of Trade at Cardiff, states that he examined the fractured coil and found it split as reported. The metal appeared to be of good quality, and the weld originally sound, and considerable pressure must have been generated in the boiler to produce rupture. The night of February 9 was exceptionally cold in Birmingham and the thermometer is said to have registered 20 deg. of frost, and Mr. Tremain says, "I have no doubt that the water was frozen in the pipes connected to the boiler, probably at a point where they passed under the door leading to the street, where they would be exposed to the cold air. No card of instructions was in possession of the man-in-charge, prohibiting the kindling of the fire or recommending that the fire be not allowed to go out during frosty weather, but ordinary precautions should have been taken to insure that the system was not obstructed by ice before the fire in the furnace was set away."

In some "observations" appended to the report, Mr. Thomas Carlton, the Engineer Surveyor-in-Chief to the Board of Trade, points out that the explosion appears to have been due to the obstruction by ice, of the heating tubes, which permitted an excessive pressure to be generated in the tubes within the boiler.

In frosty weather, Mr. Carlton says, the fires of heating apparatus should not be allowed to go out overnight, but if arrangements cannot be made to give effect to this precaution, the temperature of the boiler should not be allowed to become greater than can be borne by the hand, after the fire is lighted, until it is seen that the circulation in the pipes is not obstructed; the temperature of the pipes should also be observed from time to time, and if the return pipe becomes hot before, or at the same time as, the flow pipe, it shows that the pipe is choked, and the fire should therefore be withdrawn. Relief valves and pressure gauges are useful adjuncts for enhancing safety in working these apparatus, but they are not infallible, and their presence may prompt a feeling of security which is not warranted. Explosions such as this, however, Mr. Carlton adds in conclusion, would be obviated by the exercise of ordinary care and intelligence on the part of attendants.

CONTROL OVER EXPORTS TO SCANDINAVIA, HOLLAND AND SWITZERLAND.—The Foreign Office and Board of Trade have issued a statement as to the present position in regard to the control over exports, to Norway, Sweden, Denmark, Holland and Switzerland. The necessary particulars can be obtained from the Department of Overseas Trade (Development and Intelligence) 73 Basinghall-street, E.C. 2.

ZINC.—Zinc has been shorn of its nicknames, says *Engineering and Mining Journal*, New York. Spelter, blende, jack, and like misnomers have been cast aside. This is one of the objects which has been attained by the American Zinc Institute during its ten months' existence. Members of the Institute, numbering 140, and representing practically every zinc-mining and zinc-smelting interest in the United States, met in annual convention at St. Louis, on June 9 and 10, and among other things decided that zinc is zinc, and nothing else. Already many trade papers and the United States Geological Survey and the Bureau of Mines have agreed to call zinc by its right name.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in Italics.

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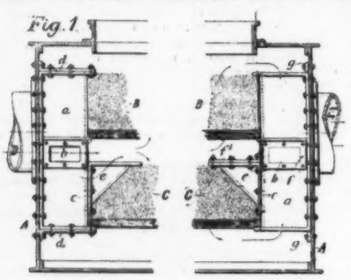
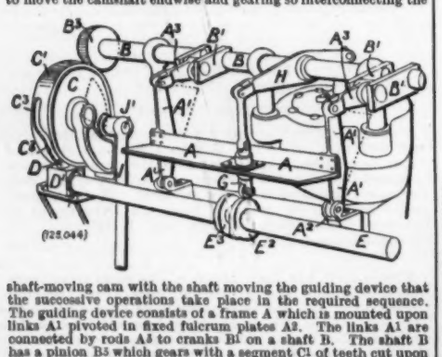
GAS ENGINES, PRODUCERS, HOLDERS, &c.

124,994. R. J. Milbourne, Newport. Gas Purifiers. (4 *Figs.*) July 12, 1918.—The invention relates to gas purifiers of the kind wherein the gas is caused to flow through the purifying material either in an upward or in a downward direction by means of reversible junction boxes arranged at the inlet and the outlet ends of the purifier. In this invention the valves heretofore used are dispensed with and in lieu thereof detachable covers for the openings in the junction boxes are employed. A indicates the body of the gas purifying chamber; B and C indicate two layers of purifying material having a space between them; D is the inlet to the purifying chamber and E the outlet therefrom. *a* indicates the junction boxes, one being furnished in conjunction with the inlet D and the other with the outlet E.



In the construction illustrated, this junction box body *a* is made rectangular and is furnished with flanges whereby it is bolted to machined facings on the side plates of the purifier body A. The upper and lower ends of each junction-box *a* are open, and each box is furnished with lateral openings *b*, and an opening *c* at the front lower part. Covers *d* are arranged for closing the upper and lower ends of each junction-box. *e* is a casting constituting a directing baffle bolted to the outside of each junction-box body *a* in front of the lower opening *c* therein, and *f*, *f*1, indicate the covers provided for closing the openings *b* and *c* in each junction-box respectively. *g* are flat strips which are provided for the purpose of protecting the machined facings on the purifier side plates when the covers *d* are not bolted in position, these strips then taking the place of the covers. (*Sealed.*)

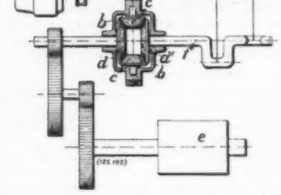
125,044. North British Diesel Engine Works, Limited, Whiteinch, Glasgow, and J. C. MacC. MacLagan, Glasgow. Reversing Valve Gear. (1 *Fig.*) December 23, 1918.—The invention relates to reversing valve gear for Diesel engines. A reversing valve gear, according to the invention comprises essentially a guiding device for the valve tappet rods co-acting with the cams so mounted that it may be moved in a direction substantially at right angles to the motion of the tappet rods and so as to bring them into engagement with and to retract them from the cams, a shaft carrying cranks adapted to move the guiding device upon rotation of the shaft, a rotatory cam adapted to move the camshaft endwise and gearing so interconnecting the



shaft-moving cam with the shaft moving the guiding device that the successive operations take place in the required sequence. The guiding device consists of a frame A which is mounted upon links A1 pivoted in fixed fulcrum plates A2. The links A1 are connected by rods A3 to cranks B1 on a shaft B. The shaft B has a pinion B5 which gears with a segment C1 of teeth cut upon a drum C, having in its periphery a cam groove C3 which is engaged by a stud D in a fixed block D1 and held between collars on the endwise movable camshaft E, on which are shown ahead and reverse cams E2, E3. The lower part G of the tappet rod which these cams alternatively operate, bears a roller which they engage, and is guided in a sleeve carried on the guiding frame A. The upper part of the tappet rod is articulated to the lower part above the guiding sleeve and at its upper end is pivoted in a jaw in a rocking lever H, mounted loosely on the shaft B, and to the opposite end of which is connected usual tappet-valve operating mechanism, which is not visible. The drum C has on it a pin J1 engaged by a connecting rod J operatively connected to hand gearing or to a barring engine. In operation, and to move the valve gear from the ahead position shown to reverse, the rod J is moved upwards, so turning the drum C. During the first part of this movement the stud D traverses that part of the cam-groove C3 which lies in the plane of rotation and which therefore serves to lock the valve gear in position. Meanwhile, the shaft B is being rotated through the toothed segment C1 and pinion B5, causing the cranks B1 to draw in the frame A, and thus moving the tappet roller out of the path of the cam E2. Upon further movement of the drum C, the stud D1 enters the inclined part of the cam groove C3, thus moving the cam E2 out of line with the tappet roller and the cam E3 into line with it. Meantime the frame A swings further inward. Upon further movement of the drum C, the stud D again enters a part of the cam groove C3 which lies in the plane of rotation, and locks the valve gear in reverse position. Final further movement of the drum C then throws the frame A forward again and the tappet roller into the path of the reverse cam E3. Reversal of the movements returns the parts to the ahead position. (*Sealed.*)

LIFTING AND HAULING APPLIANCES.

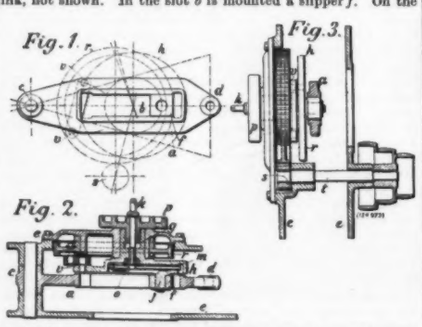
125,192. Stothert and Pitt, Limited, Bath, W. Pitt, Bath, and E. S. Franklin, Bath. Capstans. (3 *Figs.*), March 13, 1918.—This invention relates to gear for driving capstans and winches, and where it is desired to maintain a constant torque at any speed from full speed to rest. According to the invention, a hydraulic pump or an air compressor is employed as an escapement when the driven machine is overloaded, and the motor is so connected to the machine and to the pump or compressor that it normally drives the machine, but in cases of overload drives the pump or compressor, the delivery valve of the latter being so loaded that the torque required to



drive the pump or compressor is greater than the torque required to drive the machine, so as to give a predetermined pull. *a* is a motor geared to a casing *b* carrying pinions *c*, *c*, meshing with gear wheels *d*, *d*1. The wheel *d* is geared to a hoisting barrel or capstan head *e*, while the wheel *d*1 is keyed to a crankshaft *f* adapted to actuate a pair of pumps *g*, *g*, situated in a tank *h* and provided with delivery valves; these valves are so loaded that the wheel *d*1 will remain stationary unless the predetermined pull on the capstan head *e* is insufficient to haul the load in, in which case, the rotation of the head being restrained, the wheel *d*1 will be turned and the pumps will be actuated. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

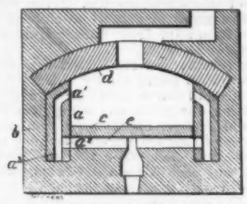
124,973. T. Lumsden, Gateshead-upon-Tyne. Machine Tools. (3 *Figs.*) June 15, 1918.—This invention relates to variable-stroke mechanisms for reciprocating machine tools with accelerated return. A machine made in accordance with this invention comprises a link carrying a slipper, one end of the link being pivotally connected to the bed of the machine and the other end being connected to the part adapted to be reciprocated, a crank disc provided with an adjustable crank-pin adapted to engage said slipper, a second crank disc disposed eccentrically of the first-mentioned crank disc, and a link between the two crank discs with means for rotating the second-mentioned crank disc. The link *a* is provided with a slot *b* and two pivotal connections *c* and *d*. The link is pivoted at *c* to the bed *e* of the machine, and is connected at *d* to the part to be reciprocated by a link, not shown. In the slot *b* is mounted a slipper *f*. On the



shaft *g* is mounted a disc *h* provided with a slot in which is disposed a crank-pin *j* adapted to engage the slipper *f*. The position of the crank-pin *j* on the crank disc *h* is adapted to be adjusted by shafts *k* and *m* and bevel gearing *o*, *o*. The shaft *m* is provided with a screw thread adapted to engage a thread in the crank-pin *j*. *p* is a flywheel on the shaft *k*. The gear wheel *r* (which may be termed the second crank disc) is mounted on the bed *e* eccentrically of the crank disc *h*, and is adapted to be driven by a pinion *s* mounted on the shaft *t*. The gear wheel *r* is connected to the crank disc *h* by a link *v*. In operation, the link *a* will be caused to oscillate on its pivotal point *c* slowly in one direction and with accelerated quick return in the other direction. In the drawing, the centre of the gear wheel *r* is shown as lying between the pivot *c* and the centre of the disc *h*, but it may be otherwise disposed. (*Sealed.*)

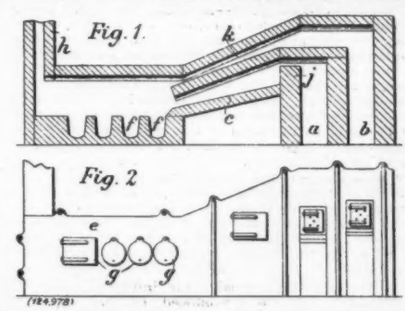
MINING, METALLURGY, AND METAL WORKING.

125,258. J. King, Sheffield, W. Gregson, Sheffield, and Tandevin and Gregson, Limited, Sheffield. Furnaces. (4 *Figs.*) May 10, 1918.—The invention consists in providing means for obviating the tendency for the gas passages of furnaces to become choked, the means consisting of specially-formed blocks with passages through them arranged between the sides of the slab floor of the heating chamber and the walls of same. The special blocks *a* are built into the furnace and abut up to the insulating brickwork *b*, both at the sides and bottom of the furnace. Thus the lower end of the blocks *a* are below the level



of the slab floor *c*, while the upper ends reach to the spring of the arched roof *d* of the furnace, but do not form part of the supports thereof. Each block *a* has one or more vertical passages *a*1 open at both ends, the upper end, however, being curved or inclined to one side, opens into the heating chamber. A transverse horizontal passage *a*2 is formed to meet each vertical passage *a*1 at a height corresponding to that of the horizontal gas flues *e* under the slab floor *c* of the heating chamber. By this formation the extreme lower ends of the vertical passages *a*1 form pockets *a*3 for the reception of any debris which may get into the gas passages. (*Sealed.*)

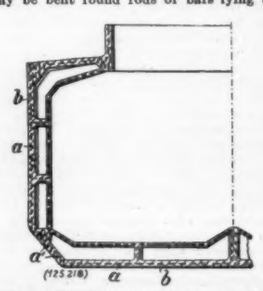
124,978. J. Wilkes, Newtown, Stockton-on-Tees, and H. E. Harris, Stockton-on-Tees. Reverberatory Furnaces. (2 *Figs.*) June 26, 1918.—This invention relates to reverberatory furnaces. A reverberatory furnace in accordance with this invention is characterised in that two fire grates are provided, the flame from one playing over the dross, and the flame from the other playing on the metal run off from the dross. *a* and *b* are grates, *c* the bed upon which the dross is charged, and *e* is a chamber provided with receptacles *f* adapted to receive the



molten metal as it flows from the dross. Doors *g* are provided in the chamber through which the molten metal can be ladled, *h* is a stack for leading off the products of combustion. The fire from the grate *a* is led over a bridge *j* and plays upon the dross placed on the sloping bed *c*. The molten metal from the dross runs into receptacles *f* in the chamber *e*. The fire from the grate *b* passes along a flue *k* and plays upon the molten metal in the receptacles *f*, from which it can be ladled from time to time. (*Accepted April* 16, 1919.)

SHIPS AND NAUTICAL APPLIANCES.

125,218. C. Hurst, Eariswood, and Queenborough Shipbuilding Company, Limited, Queenborough. Ferro-Concrete Ship. (4 *Figs.*) April 11, 1918.—According to the invention, in a ship constructed of concrete reinforced by flat metal bars embedded therein, the embedded bars having their major dimension considerably greater than their minor dimension are arranged with their wider sides substantially parallel to the skin of the concrete. The bars are interlaced, some of the bars being arranged for this purpose substantially at right angles to the other bars. By interlacing the vertical bars between the horizontal bars the necessity for wiring at the crossings is avoided since the friction at the crossings is usually sufficient to maintain the bars in place until the concrete has been poured and has set. If desired, bolts or rivets may be used at a few of the crossings to secure the bars in place, or the ends of the bars lying in one direction may be bent round rods or bars lying transversely



thereto. *a* are metal bars of rectangular cross-section embedded in concrete *b* in such a position that for the most part the major axis of the cross-section of each bar is parallel to the skin of the concrete. Thus the concrete in which the rods or bars are embedded needs to be only as thick as is necessary to resist the stresses the construction is designed to withstand. A further advantage is that the bars can be used in longer continuous lengths since by reason of their flatness they can be readily made into coils or wound on drums for transport, and straightened when put into position in the construction. Although the flat bars are in general arranged with their wider sides parallel to the skin of the concrete, they may, where necessary or convenient, be disposed as shown at *a*1 with their major axes at an angle to the skin of the concrete in order that the bars may offer the most effective resistance to the stresses which come upon them. (*Sealed.*)